Fisheries and Oceans Canada | Pêches et Océans Canada
Science | Sciences

CSAS | **SCCS**

Canadian Science Advisory Secretariat | **Secrétariat canadien de consultation scientifique**

Research Document 2009/001 | **Document de recherche 2009/001**

2008 Assessment of Pollock in 4VWX+5

Évaluation de la goberge de 4VWX+5 en 2008

Heath Stone, Cecil Nelson, Donald Clark, and Adam Cook[1]

Population Ecology Section
Biological Station
St. Andrews, New Brunswick
E3B 2L9

[1]Population Ecology Division
Bedford Institute of Oceanography
PO Box 1006, Dartmouth, Nova Scotia
B2Y 4A2

ISSN 1499-3848 (Printed / Imprimé)
ISSN 1919-5044 (Online / En ligne)

Canada

TABLE OF CONTENTS

Correct citation for this publication:

Stone, H., C. Nelson, D. Clark, and A. Cook. 2009. 2008 Assessment of Pollock in 4VWX+5. DFO Can. Sci. Advis. Sec. Res. Doc. 2009/001. viii + 79 p.

ABSTRACT

Fishery removals from the Western pollock stock component (4Xopqrs+5Yb+5Zc) averaged 6,000 t since 2000 and contributed 87% (3,469 t) and 81% (4,679 t) of total landings in 2006 and 2007, respectively. Assessment results were based on a Virtual Population Analysis (VPA) model for the Western Component that incorporated indices of abundance from both the summer research vessel (RV) survey (1984-2008) and standardized CPUE from the commercial fishery, excluding the most recent 4 years (1982-2004). Age 4+ (considered spawning stock) biomass has increased steadily from a low of 7,500 t in 2000 to 29,000 t in 2007, then declined to 27,000 t in 2008. The 2001 year class was estimated to be slightly lower than indicated during the 2006 assessment (12.4 million versus 14.5 million recruits) and has been the strongest at age 2 since the 1988 year class. Current prospects for the 2004 and 2005 year classes are very poor (< 1.5 million recruits). Reduced quotas and harvests, as well as increasing population biomass have contributed to a decline in fishing mortality rates on ages 6-9, which has been below the F_{ref} of 0.2 since 2006. The range of harvest strategies in the 2009/2010 fishing year that are risk averse (25% risk of exceeding F_{ref}) to risk neutral (50% risk of exceeding F_{ref}) are about 3,700 t to 4,400 t, but are based on recruitment levels beyond the range of past model predictions (lower than previously observed for the time series). An alternate base model formulation was examined for projections and risk analyses which assigned the lowest observed value of age 2 recruitment for the VPA time series (3.4 million) for 2006-2008. Based on this scenario, the range of harvest strategies in the fishing year that are risk averse to risk neutral are about 4,100 t to 4,750 t for age 5+. For the 2009/2010 fishing year, there is a 50% likelihood that removals of 4,500 t would not allow for any increase in biomass, reflecting the absence of incoming recruitment. These harvest strategies are for 4Xopqrs+5Zc and would be conservative if applied to all of 4X, since an additional 300-400 t of removals have occurred from 4Xmn over the past 2 years.

Landings from the Eastern Component (4Xmn+4VW) traditionally come from the Tonnage Class (TC) 4+ sector, and have been following a declining trend, although they exceeded 1,100 t in 2007. Since 1993, much of the Eastern Component was closed to cod and haddock directed fishing, which further reduced pollock landings from that area. Summer RV survey biomass, while variable, has increased since 2006. Most of this increase is due to good catches in 4Xmn, but not in 4VW. Estimates of total mortality from the RV survey indicate a decrease in Z for 2006 and 2007 due to higher abundance in the 2007/2008 surveys; however, it is too early to tell if the situation is actually improving. While the current level of removals has allowed for some rebuilding of the Eastern Component (i.e. in 4Xmn), it is not rebuilt yet (i.e. 4V). Directed pollock fisheries for the east should proceed with caution.

With the exception of the 2007/2008 div. 4W test fisheries and, to a lesser extent, 5Z, observer coverage for pollock directed mobile gear fisheries is very low, and has been implemented largely to address management issues. Notwithstanding these limitations, most of the total catch (82-99%) is landed and counted against respective quotas for these species. Dogfish appears to be the most commonly discarded bycatch species, with other species occurring at low levels. The highest amount of discarded catch appears to occur in the mobile gear fishery for redfish (4Xpq). Bycatch discards may also occur in the 4X pollock gillnet fishery, but observer coverage is far too low (i.e. 2 trips for 2006-2008) to make any conclusions. The habitat over which the directed pollock fishery takes place is highly energetic and of high complexity. The impact of the pollock fishery on the sea floor is currently unknown. The diet of pollock from the Scotian Shelf and Bay of Fundy has shown decadal changes, with euphausiids (krill) being predominant in the diet in the 1960s, less so in the 1990s, and once again since 2003.

RÉSUMÉ

Les prélèvements de la pêche parmi la composante Ouest du stock de goberge (4Xopqrs+5Yb+5Zc) se sont situés en moyenne à 6 000 t depuis 2000 et ils représentaient 87 % (3 469 t) et 81 % (4 679 t) des débarquements totaux de 2006 et 2007, respectivement. Les résultats de l'évaluation ont été fondés sur un modèle d'APV appliqué à la composante Ouest, qui intégrait des indices de l'abondance provenant du relevé par navire scientifique (relevé NS) réalisé l'été de 1984 à 2008 et des PUE normalisées de la pêche commerciale, à l'exclusion des quatre années les plus récentes (1982-2004). La biomasse des goberges des âges 4+ (considérées comme formant le stock de reproducteurs) a constamment augmenté après avoir connu un seuil de 7 500 t en 2000, pour atteindre 29 000 t en 2007; elle a ensuite diminué à 27 000 t en 2008. La classe d'âge de 2001 a été jugée légèrement plus faible que ce qu'on avait estimé dans l'évaluation de 2006 (12,4 millions de recrues au lieu de 14,5 millions); elle a été la plus forte classe d'âge à l'âge 2 depuis celle de 1988. Les prévisions actuelles au sujet des classes d'âge de 2004 et 2005 sont très basses (< 1,5 million de recrues). La baisse des quotas et des captures ainsi que la hausse de la biomasse de la population ont contribué à une diminution du taux de mortalité par pêche parmi les âges 6 à 9, ce taux étant été inférieur à la valeur $F_{réf}$ de 0,2 depuis 2006. Les stratégies de capture pour l'année de pêche 2009-2010 qui présentent un risque allant de faible (25 % de risque de dépassement de $F_{réf}$) à neutre (50 % de risque de dépassement de $F_{réf}$) sont chiffrées à environ 3 700 t-4 400 t, mais elles sont fondées sur des niveaux de recrutement supérieurs à des prédictions antérieures du modèle (qui étaient plus basses que les niveaux observés auparavant dans la série chronologique). Une autre formulation de modèle a été examinée en ce qui concerne les projections et analyses de risque associées à la plus basse valeur de recrutement à l'âge 2 observée dans la série chronologique fondée sur l'APV (3,4 millions) sur la période 2006-2008. Dans ce scénario, les stratégies de capture qui présentent un risque allant de faible à neutre pour l'année de pêche considérée sont chiffrées à environ 4 100 t-4 750 t pour les âges 5+. Pour cette année de pêche 2009-2010, il y a 50 % de probabilité que des prélèvements de 4 500 t ne permettent pas de hausse de la biomasse, compte tenu de l'absence de nouveau recrutement. Ces stratégies de capture valent pour 4Xopqrs+5Zc et elles seraient considérées comme prudentes si on les appliquait à la totalité de 4X, étant donné que de 300 à 400 t supplémentaires ont été prélevés dans 4Xmn au cours des deux dernières années.

Les débarquements en provenance de la composante Est (4Xmn+4VW) ont jusqu'ici toujours émané de la flottille des navires de la catégorie de jauge 4 + et ils ont suivi une tendance à la baisse, bien qu'ils aient dépassé 1 100 t en 2007. Depuis 1993, une bonne partie de la composante Est est fermée à la pêche dirigée de la morue et de l'aiglefin, ce qui a contribué à réduire davantage les débarquements de goberge en provenance de ces eaux. La biomasse d'après le relevé NS d'été, quoique variable, a augmenté depuis 2006. La majeure partie de cette hausse est due à de bonnes prises dans 4Xmn, mais non dans 4VW. Les estimations de la mortalité totale d'après le relevé NS dénotent une baisse de Z en 2006 et 2007, reflétée dans la plus forte abondance observée dans les relevés de 2007-2008, mais il est trop tôt pour savoir s'il y a là une réelle amélioration de la situation. Bien que le niveau actuel de prélèvements ait permis un certain rétablissement de la composante Est (dans 4Xmn), celle-ci ne s'est pas encore reconstituée, comme le montre la situation dans 4V. Les pêches dirigées de la goberge dans la composante Est devraient donc être guidées par la prudence.

Sauf en ce qui concerne les pêches d'essai pratiquées en 2007-2008 dans 4W et, dans une moindre mesure, dans 5Z, très peu d'observateurs sont présents dans les pêches dirigées de la goberge aux engins mobiles et ceux qui sont embarqués le sont dans une large mesure pour régler des problèmes de gestion. Malgré cette insuffisance, la plupart des prises totales (de 82 à 99 %) sont débarquées et défalquées des quotas respectifs des espèces capturées. Les rejets les plus courants semblent être ceux qui vivent les prises accessoires d'aiguillat, les rejets d'autres espèces étant faibles. C'est dans la pêche du sébaste aux engins mobiles (dans 4Xpq) que les rejets de prises semblent être les plus élevés. Il se peut que des prises accessoires soient aussi rejetées dans la pêche de la goberge au filet maillant dans 4X, mais la présence d'observateurs dans cette pêche est

bien trop insuffisante (n'ayant porté que sur deux sorties de 2006 à 2008) pour qu'on puisse tirer quelque conclusion que ce soit. L'habitat des fonds sur lesquels se déroule la pêche dirigée de la goberge se caractérise par une grande énergie et une vaste complexité. On ne sait pas actuellement quelle est l'incidence de la pêche sur le fond marin. Le régime alimentaire de la goberge sur le plateau néo-écossais et dans la baie de Fundy a changé au fil des décennies, les euphausiacés (le krill) y occupaient une place prépondérante dans les années 1960, moindre dans les années 1990 et dominante à nouveau depuis 2003.

INTRODUCTION

Pollock in the management unit (Northwest Atlantic Fisheries Organization (NAFO) divisions) 4VWX+5 are assessed as Western (4Xopqrs+5Yb+5Zc) and Eastern components (4VW+4Xmn), following the recommendations of the framework assessment completed in 2004 (Neilson et al. 2004) (Fig. 1). This Research Document updates the last stock assessment for pollock in the Western Component completed by Stone et al. (2006), and includes updated information for 2006 (fishery data: Trimester 3), 2007 (survey and fishery data: Trimesters 1-3) and 2008 (survey and fishery data: Trimesters 1-2).

Advice was requested by Department of Fisheries and Oceans (DFO) Fisheries and Aquaculture Management Branch on the stock status of pollock to inform management of the 2009/2010 fishery. The Terms of Reference for this Science Advisory Process peer review were to:

- Review and evaluate biological and fishery information on 4VWX+5 pollock stock status to be used as the basis for establishing the Total Allowable Catch (TAC) for the 2009/2010 fishery.
- Update the advice using the 2004 assessment framework and the latest information from fisheries and research surveys.
- Evaluate the impact of pollock and the pollock fishery in an ecosystem context, including:
    - Descriptions of bycatches.
    - Comment on possible benthic impacts.
    - Update information on pollock predator/prey interactions.

THE FISHERY

Landings of pollock for the Western Component of the management unit (4Xopqrs+5Yb+5Zc) in fishing years ending 31 March 2007, and 31 March 2008, were 3,768 t and 4,411 t, respectively, against quotas of 4,500 t and 5,000 t (Fig. 2). Landings from the west for 2008 are currently at 3,332 t (Apr.-Dec., quota = 5,000 t). Calendar year landings were used for the analytical assessment and for 2006, 2007, and 2008 were 3,965 t, 5,799 t, and 4,096 t (Jan.-Aug.), respectively (Table 1). Landings from Eastern Component (4VW+4Xmn) represented over half the catch up to 1990, but have declined significantly, and in 2003 dropped to 243 t. In the fall of 2007 and 2008, the mobile gear sector was allowed to participate in a test fishery in 4Vs and 4W, which resulted in landings of 586 t and 373 t, respectively. Overall, the TAC has rarely been restrictive except for a 5 year period in the late 1980s and, more recently, since 2004 (Fig. 2).

The pollock fishery has had significant changes in both area fished and in dominant gear type. The Western Component of the management unit usually contributes the largest proportion of the total landings (> 80% since 2000) (Fig. 3, Table 2). Landings from the Eastern Component traditionally came from the TC 4+ sector, and have followed a declining trend since 1990 (Fig. 3; Table 3). Since 1993, much of the Eastern Component has been closed to cod and haddock directed fishing, which further reduced pollock landings from that area. Landings from the Western Component now come mostly from unit areas 4Xpq, and have declined substantially from the Bay of Fundy (4Xrs+5Yb) and Georges Bank (5Zc) since 2003 and 2004, respectively, and off southwest Nova Scotia (4Xo) since the mid 1990s (Fig. 4; Table 2). The seasonal pattern of the fishery over the past 3 years for the west was similar to previous years, with most pollock catches occurring from May through September (Table 4). Occasionally, winter fisheries have occurred with high landings in January and February (i.e. 1986-1988, 1991, 1993, and 2005).

The mobile gear fishery (OTB (otter trawl bottom) 1-3) in 2007 and 2008, occurred mainly in Crowell and Jordan basins (**4Xpq**), northeastern Georges Bank (5Zc), the outer Bay of Fundy (**4Xrs**), along shelf slope, and east of LaHave Bank (**4Xn**) (Fig. 5). During the fall of 2007 and 2008, there was a test fishery in 4W, which occurred in Emerald Basin and along the shelf slope south of Emerald Bank. Gillnet catches for 2007-2008 were mainly from the Jordan Basin area (**4Xq**), although there were also catches from northeastern Georges Bank (5Zc), Baccaro and LaHave banks (**4Xn**), and around the edges of LaHave (**4Xm**) and Emerald basins (4Wkl) (Fig. 6). Generally, the gillnet fishery had a similar spatial distribution for both years. As indicated by Neilson and Perley (2005), the overall distribution of catches in recent years has contracted since the early 1990s.

Since the early 1980s, the small mobile gear component (OTB 1-3) has accounted for most of the total landings, followed by gillnet (Fig. 7; Table 5). The percentage of total landings taken by gillnets has declined since 2000, while the small mobile share has increased. Currently, the gillnet share is 22% and small mobile is 75%; however, both gear sectors are also limited by their respective quotas. The contribution of larger trawlers to total landings (OTB 4+) has been steadily declining since the mid 1990s, but showed a modest increase from 2% in 2005 to 6% in 2006. The offshore sector was using smaller vessels (TC 1-3, under the Temporary Vessel Replacement Program (TVRP)) to catch their allocation. The TVRP category is currently no longer in existence as a quota group for pollock (as of the 2008-2009 fishing year), and there have been no TC 4+ vessels involved in the fishery since 2007. The contribution by the longline/handline sector has also declined since the mid 1990s, but there has been a modest increase (3% of total landings) over the past few years.

Industry Perspectives

A data input review meeting was held in Bridgewater, Nova Scotia, on 21 October 2008, during which the fishing industry made several comments about the 2007-2008 pollock fishery. The main points are summarized below:

- With the low quota, pollock is essentially a bycatch, and fixed gear fishers try to make their allocations last as long as possible throughout the year. Since it has been difficult to avoid pollock in the past few years, gillnet fishers ha been using up their allocations relatively quickly, even when trying to fish areas where they can catch more cod rather than pollock. One gillnet fisher reported that catches of pollock on Georges Bank are very good, even when using 7" mesh. Unlike the past, it is now difficult to avoid them and they can be caught outside of the traditional "deep water" fishing area on the bank.
- For the past 2 years, the longline sector has been experiencing catch rates similar to the 1980s. Longline fishers are seeing good catch rates in their fishery and are concerned about catching too much pollock all at once.
- Some mobile gear vessels have not been directing for pollock, but may make a few sets near the end of a trip to "round" it out. The 2007 and 2008 catch rates were not considered to be representative of abundance.
- The July research vessel (RV) survey does not cover the entire geographic area of the pollock fishery. Georges Bank is not sampled at all during the summer survey, a time when mobile and fixed gear vessels are catching pollock on the bank. Since 2000, landings from 5Zc have represented 20% of the total catch. The RV survey does not include this biomass.

- Industry feels that there is as much pollock now as there was back in the "heyday". In their opinion, a quota of 10,000 t is sustainable.
- One participant representing the offshore sector (which holds 50% of the pollock quota) expressed concern about a joint assessment and TAC agreement with the US and indicated that they would not be in favour of this approach.

SAMPLING AND CATCH/WEIGHT AT AGE

Port (shore) and observer (at-sea) sample collections contributed to several thousand pollock length measurements annually from 2006-2008 (Table 6). Sampling was considered adequate to characterize the catch at size and catch at age (CAA) for the Western Component, with 1,111 and 1,649 ages available for the 2006 and 2007 fisheries, respectively, and 1,194 ages available to the end of the second trimester in 2008. Length and age data was also available for mobile gear fisheries in the Eastern Component (i.e. in 4Xmn and 4W) for 2007 and 2008, but not for fixed gear fisheries (which may land over 200 t annually). This difference occurs because there is currently no commercial port sampling available east of Shelburne, Nova Scotia. Fixed gear vessels fishing in the Eastern Component that land their catches east of Shelburne would not be sampled; however, mobile gear vessels fishing in the east often land their catches in southwest Nova Scotia ports and, therefore, may be sampled.

Comparisons of 2007 and 2008 port and observer length measurements of pollock from the directed fishery were made for months, areas, and gear types, where both types of samples were available. For the most part, these comparisons showed similar catch size frequencies of pollock. An exception was 5Zj in 2008, but observer sampling for this area was low (Fig. 8). Pollock are also captured in the small mesh (cod end mesh < 130 mm) 4Xpq redfish fishery. Comparisons of 2008 port and observer length measurements generally indicated different size compositions of pollock, with small fish (30-40 cm) observed at-sea, but not in port sample collections (Fig. 9, upper panel). This difference may indicate high-grading or discarding of small pollock from the 2008 redfish fishery. If this is the case, then the CAA for smaller, younger pollock would be underestimated. Vessels directing for redfish should leave the Crowell/Jordan Basin area (Fig. 9, lower panel) when catch rates of small pollock (i.e. < 40 cm) are high.

The level of commercial fishery sampling was relatively low in the 1970s in 4X; thus, the assessment presented here starts in 1982, when the level of sampling improved to reflect the fishery more accurately. To construct the catch at age for 2008 (Trimesters 1 and 2), 2007 (Trimesters 1-3), and to update the CAA for 2006 (with data from Trimester 3), data for the Western Component was aggregated to the trimester level by gear type and tonnage class. Area 4Xu was prorated over the Western Component by allocating the proportion of landings attributed to 4Xmn versus the remaining unit areas in 4X. Samples were aggregated on a trimester basis for all gear sectors (OTB 1-3 large mesh (cod end mesh ≥ 130 mm), OTB 1-3 small mesh (cod end mesh < 130 mm), gillnet, OTB 4+, and longline/handline gear). Small pollock are caught in the small mesh mobile gear used in the 4Xpq redfish fishery, so this gear type was kept separate in the CAA. Length-weight parameters were calculated from data pooled over the last 10 years from the summer RV survey for stratas 474, 476, and 480-495 (the Western Component). Since no surveys were conducted in the spring or fall, the summer value is used for all 3 trimesters.

In order to evaluate the consistency of age determinations, the primary ager for the 4VWX+5 pollock stock re-aged otolith sections used during a Canada/US ageing workshop in 2001. Agreement with prior Canada/US consensus ages was 92% (Between Ager Comparison, Fig. 10). In a second comparison using otolith sections from the 2007 Canadian fishery, the

primary ager conducted self testing (Within Ager Comparison, Fig. 10), which yielded 89% agreement. Based on these comparisons, it was concluded that current pollock age interpretations are consistent and have no appreciable bias.

Larger pollock were captured by gillnet and handline/longline (average: 65-67 cm fork length (FL)) compared to large mesh mobile gear (average: 58-61 cm FL) (Fig. 11, upper panel). The small mesh mobile gear (used in the 4Xpq redfish fishery) captured a greater proportion of pollock < 46 cm FL, especially in 2008. The age composition of the catch differed among gear types, ranging from 5-8 for gillnet and handline/longline, 3-7 for large mesh mobile, and 2-7 for small mesh mobile gear (Fig. 11, lower panel).

Strong and weak year classes are apparent in the age structure, and cohorts are readily tracked (Table 7; Fig. 12). Diminished numbers at age for older ages, a feature which first appeared in the 1990s, continues to the present. The 2008 fishery is dominated by ages 5, 6, and 7; the 2003, 2002, and 2001 year classes, respectively. The most recent strong year classes apparent in the fishery are the 1999 year class (white circles) and the 2001 year class (yellow circles). Both have made significant contributions to the Western Component fishery over the past 4 years, and the 2001 year class continues to be important at age 7 in 2008.

In general, fishery weights at age (WAA) have been decreasing since the early 1980s, but seem to be levelling off or increasing now (Table 8; Fig. 13). In 2008, there was slight increase in WAA for ages 3, 4, and 6, and slight decrease for ages 5 and 7.

INDICES OF ABUNDANCE

Commercial Fishery Catch Rates

Commercial fishery catch rates (CPUE) for small mobile gear (TC 1-3) are used as tuning indices in this assessment, and are based on individual standardized catch rates from 4 areas in the Western Component: 4Xq, 4Xp/5Zc, Bay of Fundy (4Xrs and 5Yb), and 4Xo. The main criteria for trips included in catch rate analyses is that they must be pollock directed (> 50% of total catch is pollock) and the vessel must have 5 or more consecutive years in the fishery. A multiplicative model (Gavaris 1980, 1988a) with main effects of year (1982-2008), CFV number, month, and cod end mesh type (diamond or square) was solved using standard linear regression techniques after *ln* transformation of nominal CPUE (t/hr) data:

$ln(\mathrm{CPUE}_{ijkl}) = \mu + \mathrm{Year}_i + \mathrm{Month}_j + \mathrm{Vessel}_k + \mathrm{Mesh\ Type}_l + e_{ijkl}$

Analysis of variance results indicated that for each area, the overall regression and individual main effects were significant ($P < 0.5$), and that the model explained between 36-49% (multiple r^2) of the variability in the data. A weighting factor was applied to the standardized catch rates for each of the 4 areas to account for changes in the spatial distribution of fishing activity (after Walters 2003), then they were averaged together to generate a single index for the Western Component. The weighting factor for each area was calculated as the number of productive 10' squares in that area in 1992 (a year of high landings) divided by the total number of productive 10' squares in all areas in 1992.

There has been a general declining trend in standardized catch rates for all areas since the early 1980s, followed by an increase after 2001 (Fig. 14, upper panel). Area 4Xp/5Zc has had the highest catch rates since 2001, reaching a peak in 2007 before declining in 2008. Catch rates for 4Xq, the next highest area, declined between 2003 and 2006, but have increased

sharply since then; while for the Bay of Fundy, catch rates have been declining since 2003. Area 4Xo has had very few trips since 1997, so this series has been set to "0" in the CPUE index from 1998 to present. The area-weighted CPUE for all areas combined reached the second lowest level in the time series in 2006, with the lowest occurring in 1998 (Fig. 14, lower panel). Since 2006, catch rates have been higher but variable. Catch rates from 2005 to 2008 were constrained by reduced quotas and changes in fishing practices and are not comparable to those earlier in the time series. The current view is that since 2004, this series may no longer reflect trends in relative abundance.

The age-specific indices of abundance from the mobile gear sector of the fishery indicate a reduction in the abundance of older (ages 7+) fish since 1996, with modest signs of improvement in age structure beginning in 2006 (Table 9; Fig. 15). The 1999 year class is noteworthy from 2003-2007 and continues to be present at age 9 in 2008. The 2001 year class is predominant in 2007 at age 6 and in 2008 at age 7. Both the 2004 and 2005 year classes at age 3 look stronger than the previous 2 year classes at this age.

DFO Research Vessel (RV) Survey

Indices from the summer DFO research vessel survey based on 4X strata 474, 476, and 480-495, are used in the assessment of the Western Stock Component. The time series begins in 1984, the first year that the *RV Alfred Needler* was used for the summer survey program. The 2006 summer survey biomass index was at the highest observed level in the time series and, although this was an obvious year effect, there has been a general increasing trend since 2002, which persists through to 2008 (Fig. 16). Strong year-effects are present in other years as well (i.e. 1988, 1990, 1996) and reflect the semi-pelagic schooling behaviour of pollock and changes in q. In 2007 and 2008, several good catches occurred in the Western Component area off southwestern Nova Scotia (4Xpq) (Fig. 17). There were also good catches in the Eastern Component along the Shelf edge, and around LaHave Basin (4Xmn). However, with the exception of 2 good sets along the Laurentian Channel in 2007, survey catches in the central (4W) and eastern (4V) shelf area were quite low.

Consistent with the catch rate information, the DFO RV indices for the Western Component show that the 1999 year class appears strong from 2003 to 2007; however, not many are left by age 8 in 2008 (Table 10; Fig. 18). The 2003 year class (age 5) and the 2002 year class (age 6) are predominant in 2008, and the 2001 year class at age 7 is also noteworthy. More older fish are present now than in the past (i.e. ages 7 and 8), but incoming recruitment (i.e. 2004 and 2005 year classes at age 3) appears to be weak. The record high indices at all ages in 2006 should be interpreted with caution, since indices for all year classes are inconsistent with values seen previously.

RV survey weights at age (equivalent to mid-year population WAA) follow a declining trend from the early 1980s to late 1990s (Fig. 19). Since the late 1990s, WAA has been increasing for ages 2-5, but declining for ages 6 and 7, until this year. In the 2006 assessment, there was some concern that survey weights at age did not appear to have the same declining trend evident in the fishery weights at age for age 5+ (Fig. 13), and that fishery WAA may be influenced by changes in fishing patterns. Since 2006, the fishery WAA has increased for most age groups, so this difference may no longer be an issue.

Other Survey Indicators

The Individual Transferable Quotas (ITQ) survey is not used as a tuning index, but it provides qualitative information to compare with the DFO summer survey. In 2007 and 2008, there were very low catches of pollock compared to the 10-year average. Only 2 tows with good catches occurred in 2008 in 4Xpq, with very low catches in 4Xmn compared to 2007 (Fig 20). Trends in biomass between the DFO summer survey, the CPUE series, and the ITQ survey show some concurrence; however, the ITQ survey tends to be much more variable than the other 2, and shows a strong decline after 2006 to low levels in 2007 and 2008 (Fig. 21). This is inconsistent with the DFO survey and CPUE series for the recent period; therefore, the ITQ series may not be that useful for trend comparisons.

The National Marine Fisheries Service (NMFS) has conducted stratified random surveys during spring and fall in the Gulf of Maine since the 1960s. The 2008 NMFS spring survey shows good catches in the western Gulf of Maine and northeastern Georges Bank; however, the 2007 NMFS fall survey had low catches in the western Gulf of Maine and no catches on Georges Bank (Fig. 22). There was only one good set from this survey, which occurred in Jordan Basin. The 5 year average for both series indicates that catches occur across international boundary and that there is continuity with the Western Component in 4X. The NMFS fall survey biomass index shows a general trend of increasing pollock biomass in the Gulf of Maine from 2001 through 2005, but it drops off in 2006 and 2007 (Fig. 23). The NMFS spring series is contrary, and indicates that biomass has been increasing in recent years and supports recent biomass trends observed in the DFO survey. The most recent NMFS assessment for the Gulf of Maine (sub-areas 5 and 6) pollock stock conducted in 2008 (based on catch statistics and fall survey biomass series) suggests that this stock is overfished and that overfishing is occurring.

ESTIMATION OF CURRENT POPULATION STATE

Two VPA runs were conducted using the framework assessment formulation of Neilson et al. (2004), with a few modifications. The Base Model formulation (accepted for the 2006 assessment) used CAA for ages 2-13 (1982-2008), RV indices for ages 3-8 (1984-2008, proportional fit), truncated CPUE indices for ages 3-8 (1982-2004, power fit), and natural mortality of 0.2. The truncated CPUE series excluded 2005-2008, years which had more restrictive quota, fewer pollock-directed trips, and considered by industry to be unrepresentative of abundance trends. The Framework Model (used here for comparison only), had the same formulation as the Base VPA, but used the full CPUE series for 1982-2008. The adaptive framework, ADAPT (Gavaris1988b), was used to calibrate the sequential population analysis with the CPUE and RV survey age-specific abundance trend results. For this assessment, age 2 was assigned a fixed value based on recent observed recruitment (i.e. geometric mean of past 10 years), and fishing mortality at age 9 for 2007 and 2008 was assumed to be equal to the population number weighted average fishing mortality on ages 7 and 8.

Diagnostics

Results for population abundance, F, and biomass are given in tables 11-13, respectively, for the Base VPA, and in tables 14-16 for the Framework VPA. A comparison of VPA model results indicates that age 2 recruitment for the 1999-2003 year classes is higher for the Base VPA compared to the Framework VPA, but lower for the 2004 and 2005 year classes (Fig. 24). Also, age 4+ biomass for the Base model is higher from 2003 on, and shows a steady increase to 2007, declining slightly in 2008. The 2008 4+ biomass is estimated at 27,400 t (versus 20,200 t

for Framework VPA). Fishing mortality on ages 6-9 is slightly lower in the Base VPA and drops below F_{ref} in 2007.

The Base VPA is considered to be a better approach, because it excludes 2005-2008 from the catch rate series, which are not considered to be comparable to other years in the time series. The mean square residuals for the Base model (MSR = 0.665163) is slightly higher than the Framework model (MSR = 0.651211), indicating that the fit of the Base model to the survey indices is not quite as good. However, when the entire CPUE series is omitted and only the RV series is used for tuning, the MSR increases to 1.025038. During the 2004 framework assessment, it was concluded that it is useful to have the catch rate series as a tuning index to dampen the year effects apparent in the RV series. This conclusion continues to be valid for the current assessment.

Age-specific residuals for the Base VPA formulation are shown in Fig. 25. The residual pattern for the CPUE series (upper panel) shows a band of positive residuals for ages 4-6 from 1994 to 2004. The model predicts higher abundance than indicated by the CPUE series for ages 3, 4, 7, and 8 in 2004. Residuals for the RV series are large and positive for most ages in 2006 (year effect). Large negative residuals occur for ages 7 and 8 in 2008, with the model predicting higher abundance for these age groups than indicated by the survey indices.

The population abundance estimates for the Base VPA show a decreasing trend in relative error in model fit and relative bias for ages 3 through 7, with a slight increase in relative error bias for age 8 (Table 17). However, the relative error for ages 3 (1.765) and 4 (0.830) appears to be quite high and indicates high variability in the estimates of population abundance for these ages. Survey calibration constants (q's) increase with age up to age 7, then decline at age 8. While the age-specific estimates of population numbers and calibration constants are sometimes associated with high variance, they are comparable to those reported in the assessment of this resource in 2006. The CPUE calibration coefficients show high relative error at ages 3 and 4, but these indices are fit to the model using a power function and the coefficients appear to be poorly estimated.

Retrospective analysis for the Base Model VPA indicates a slight tendency to underestimate fishing mortality on ages 6-9, to overestimate 4+ stock biomass, and to underestimate age 2 recruitment (Fig. 26). Overall, however, there is not a strong retrospective pattern for this model formulation. A comparison of age 3+ population biomass from the Base VPA and *q*-adjusted age 3-8 total biomass from the RV survey indicates a relatively good fit of the population model to the survey data, despite the several year effects evident in the survey time series (Fig. 27).

Stock Trends and Current Status

The assessment results were based on the Base age-structured population model for the Western Component that incorporated indices of abundance from both the DFO summer RV survey (1984-2008) and standardized CPUE from the commercial fishery, excluding the most recent 4 years (1982-2004). The model set up for the terminal year involves estimating abundance for ages 3-8, calculating a weighted F for ages 9 and 10 (using the average for ages 7 and 8), and assigning a small value for the abundance of ages 11-13.

The 2001 year class was estimated to be slightly lower than indicated during the 2006 assessment (12.4 million versus 14.5 million recruits) and was the strongest at age 2 since the 1988 year class (Fig. 28). It is also the third highest in the time series. Initial indications for both the 2002 and 2003 year classes are that they are of average strength at 7.1 and 6.3 million

(geometric mean for time series = 6.7 million). However, current prospects for the 2004 and 2005 year classes are very poor (1.3 and 1.5 million, respectively).

Estimates of age 4+ (considered spawning stock) biomass declined from about 66,000 t in 1984 to about 7,500 t in 2000. Biomass has been rebuilding since 2000, increasing steadily to about 29,000 t in 2007, and declining to 27,000 t in 2008 (Fig. 28). During the benchmark review, it was concluded that the probability of good recruitment is higher when adult biomass is $> B_{ref} = 30,000$ t. This conclusion was based on the relationship between age 4+ biomass and age 2 recruits, which, when examined visually, gives an indication that recruitment may be higher when age 4+ biomass exceeds 30,000 t (Fig. 29). If this is the case, then current levels of age 4+ biomass are below the reference level.

Gains in fishable biomass may be partitioned into those associated with somatic growth of pollock which have previously recruited to the fishery and those associated with new recruitment to the fishery (Rivard 1980). Age 3 was used as a convenient age of first recruitment to the fishery. On average, growth contributes about 70% of total production, ranging from 60-90% since 1982 (Fig. 30). Surplus production is defined as the gains in fishable biomass which are in excess of the needs to offset losses from natural mortality. When the fishery yield is less than the surplus production, there is a net increase in the population biomass. Since 1999, there has been a moderate level of production in excess of fishery removals up to 2006. In 2007, surplus production was estimated to be low at 2,770 t compared to 9,074 t in 2006. The yield for age 3+ increased steadily from 1994 to 2004, but has declined since then, and was estimated at 4,051 t in 2007, a modest increase from 2006.

Fishing mortality rates steadily increased from the early 1980s, to above 1.0 by the early 1990s and remained high until the early 2000s. Subsequent reduced quotas and harvests, as well as increasing population biomass, have contributed to a decline in the fishing mortality rate on ages 6-9, which has been below the F_{ref} of 0.2 since 2006 (Fig. 31). The overall prognosis is not quite as optimistic as indicated from the 2006 assessment.

PROJECTIONS OF CATCH AND POPULATION BIOMASS

Projections were done using the Base VPA results, and a 3-year average (2006-2008) for partial recruitment (except age 4), fishery WAA, and beginning of year WAA. Unlike other 3-year partial recruitment (PR) average values, the 3-year average PR for 2006-2008 increases for all ages, and especially for age 4 (Fig. 32). The latter reflects the low fishery catch at age 4 in 2008. The high PR value for this age group is not considered to be a likely scenario, therefore, age 4 PR was assigned a value of 0.35 for projections and risk analysis. The partial year (2008, Jan.-Aug.) was included in all calculations because in previous years, the increment of growth observed in the final trimester was inconsequential. Recruitment was set at 5 million for 2009 and 2010. It was assumed that removals for the remainder of quota year (31 March 2009) would be about 1,400 t, with removals at F_{ref} for the next fishing year (2009/2010). The projected age 4+ population biomass is estimated at 23,400 t for 2009 and 24,500 t for 2010, but is influenced by assumed recruitment. Age 5+ biomass is expected to decline from 22,200 t in 2009 to 20,300 t on 2010. The projected 2+ yield in 2009 is estimated at 4,100 t (Table 19); with the 2001 year class at age 8 representing 36% of the catch biomass.

For the Western Component, the range of harvest strategies in the fishing year that are risk averse (25% risk of exceeding F_{ref}) to risk neutral (50% risk of exceeding F_{ref}) are about 3,700 t to 4,400 t for age 5+ (Fig. 33). For the 2009/2010 fishing year, there is a 50% likelihood that removals of 3,000 t would not allow for any increase in biomass.

Given the high variability in relative error for the current population abundance estimates of ages 3 and 4 (Table 17), and the fact that the abundance of the 2004 and 2005 year classes at age 2 (1.3 and 1.5 million, respectively) was estimated to be lower than previously observed for the entire time series (i.e. beyond the range of past model predictions), an alternate base model formulation was examined for projections and risk analyses. For this model, the population abundance at age 2 for 2006-2008 was assigned the lowest observed value of recruitment for the time series (3.4 million). Based on this scenario, the range of harvest strategies in the fishing year that are risk averse (25% risk of exceeding F_{ref}) to risk neutral (50% risk of exceeding F_{ref}) are about 4,100 t to 4,750 t for age 5+ (Fig. 34). For the 2009/2010 fishing year, there is a 50% likelihood that removals of 4,500 t would not allow for any increase in biomass.

EASTERN COMPONENT

While most of the fishery now occurs within the Western Component, there remains a need to provide advice on the status of the resource on the Eastern Component, especially in light of the mobile gear test fisheries in 4W in 2007 and 2008. The distribution of catches from the 2007 and 2008 RV surveys is shown in Fig. 17. Several good catches occurred in eastern 4X in 2007 and 2008; these were along the shelf edge (4Xn), around Emerald and LaHave basins, and along the line separating Eastern and Western components. Two good tows also occurred in 4V along the edge of the Laurentian Channel in 2007, but there were no good catches in 4V in 2008.

In 2007, survey biomass in the Eastern Component increased to a level not seen since the early 1990s, and represented 62% of total biomass (versus 38% for Western Component) (Fig. 35). Most of this increase is attributed to higher catches from sets in eastern 4X (i.e. 4Xmn), not in 4VW. Biomass declined in the east in 2008, but was still relatively high compared to the past decade. The overall biomass for the 4VWX+5 stock complex has remained relatively high since 2006.

DFO summer survey age-specific indices of abundance for the Eastern Component (strata 440-474, 475, 477, and 478; Fig 36) generally indicate a different pattern of year class strength compared to the west (stratas 474, 476, 480-495; Fig. 18). The 2004 year class at age 4 is predominant in 2008, while the 2002 year class at age 5 is strong in 2007 (similar to CAA for 4W; see Fig. 40). Ages 3 and 4 in 2008 and 2007 also appear to be of greater strength compared to the west for these years; however, the strong year effect in 2006, which caused high abundance for all age groups in the west, is not evident in this series. The survey indices also show that there have been relatively few fish older than age 7 since 1997. A comparison of survey weights at age for ages 2, 4, and 6 indicates that pollock from Eastern Component strata generally weigh less for these age groups compared to pollock from Western Component strata (Fig. 37).

Despite minimal landings from the Eastern Component, smoothed estimates of total mortality from the RV survey were high and increasing up to 2005, declined in 2006, then increased again in 2007 (Fig. 38). This recent pattern is likely due to higher abundance in 2007 and lower abundance in 2008. It is difficult to tell from the survey Z if situation in the east is actually improving.

Pollock catch at size and catch at age frequencies from directed fisheries in area 4W during the 1980s and 1990s were examined to see how they compared with the size and age composition from recent (2007/2008) test fisheries in 4W. Length-weight parameters were calculated from

data pooled over the last 10 years from the summer RV survey for stratas 440-473, 475, and 477-478. Pollock were larger in the 1980s compared to 1990s (Fig. 39). Size frequencies from 2007/2008 test fisheries appeared to be similar to both earlier periods, when fisheries took place on the eastern Scotian Shelf. Pollock from the 2008 test fishery were smaller than those landed in 2007 (modal size: 49 versus 55 cm).

The age composition from the 1980s and 1990s indicates that fish as young as age 3 and 4 represented a considerable percentage of the catch (Fig. 40). During this period, 130 mm diamond mesh cod ends were used for the directed fishery and were capable of retaining small pollock. Noteworthy is that after the mid 1990s, relatively few fish older than age 6 have been captured.

The 2007 test fishery in 4W was represented mainly by fish aged 5 and 6 (2003 and 2002 year classes, respectively), while in 2008, age 4 (2004 year class) comprised much of the catch. A similar age frequency pattern was observed in the RV survey indices for the Eastern Component strata (See Fig. 36).

ECOSYSTEM IMPACTS

Bycatch Analyses

The percentage of bycatch kept and bycatch discarded was calculated as a proportion of the total observed catches for 2006-2008 combined (3 years since last assessment). For pollock-directed fisheries, the catch composition was examined for observed OTB 1-3 trips in 4X, 5Z, and 4W (test fishery), and also for gillnet trips in 4X. For pollock bycatch fisheries, observed trips from the 4X redfish fishery were examined, since this fishery has landed an average of 475 t of pollock over past 3 years. Other groundfish fisheries (i.e. cod, haddock) also catch pollock, but since the pollock bycatch exceeded that of the directed species, these trips were not examined further.

A proxy for observer coverage for each fishery/gear category was calculated as the observed catch (t)/total landings (t) X 100. Generally, observer coverage has been low for pollock directed and pollock bycatch fisheries; the only exception being the 4W test fishery with 100% observer coverage. Over the past 3 years, observer coverage of the directed mobile gear fisheries for pollock in 4X and 5Z has declined to very low levels (i.e. to 1% by 2008), and only 2 gillnet trips in 4X were observed over the past 3 years. In the 4X redfish fishery, observer coverage has declined from 5% in 2006 to only 1% in 2008, and, as indicated earlier, there is the potential for discarding of small pollock in this fishery.

Gear Category (species sought)	**% Observer Coverage** *(observed catch/total landings x 100)*		
	2006	***2007***	***2008***
4X OTB (Pollock)	2.8	2.9	1.1
5Z OTB (Pollock)	38.7	7.9	0.6
4W OTB (Pollock)	-	100.0	100.0
4X GN (Pollock)	-	-	1.9
4X OTB (Redfish)	4.7	3.8	1.1

For pollock-directed mobile gear trips in 4X, observed sets occurred in Crowell Basin and the Fundian Channel (Fig. 41). Overall, 96% of the catch was kept and 4% was discarded. Pollock represented 92% of the total catch with very little bycatch, i.e. 2% haddock, 1% cod, and < 1% redfish and white hake, all of which were landed (Fig. 41). Discarded bycatch species included dogfish (2%), basking shark (2%), and American lobster (<1%), plus several other species at very low levels (Table 19).

For pollock-directed mobile gear trips in 5Zc, observed sets occurred along the northeastern edge of Georges Bank (Fig. 42). Overall, 99% of the catch was kept with 1% discarded. Pollock represented 91% of total catch with very little bycatch: 7% haddock, 1% cod, and < 1% redfish, all of which were landed (Fig. 42). Discarded bycatch species included dogfish (1%), barndoor skate (< 1%), and American lobster (< 1%), plus several other species at very low levels (Table 20).

For pollock-directed mobile gear trips in 4W, observed sets occurred in Emerald Basin and along the Shelf slope (Fig. 43). Overall, 99% of the catch was kept and 1% was discarded. Pollock represented 98% of total catch, redfish 1%, haddock and cod < 1%; all were landed (Fig. 43). The discarded bycatch species was mainly "Russian hat" sponges (1%), plus several other species at very low levels. Generally there was very little bycatch in this fishery (Table 21).

For pollock-directed gillnet trips in 2008, observed sets occurred mainly in 4Xq around Jordan Basin (Fig. 44). Overall, 82% of the catch was kept, with 18% discarded. Pollock represented 61% of total kept catch with a bycatch of 15% white hake, 4% cod, 2% shortfin mako, and < 1% thresher shark, all of which were landed (Fig. 44). Discarded bycatch species included basking shark (14%), spiny dogfish (1%), white hake (1%), pollock (1%), plus several other species at low levels (i.e. cod, American shad, blue shark; Table 22).

For redfish-directed mobile gear trips in 4X, observed sets occurred in Crowell, Jordan, and LaHave basins (Fig. 45). Overall, 87% of the catch was kept, with 13% discarded. Redfish represented 58% of total catch, pollock 22%, haddock 3%, cod and white hake approximately 1%; all were landed (Fig. 45). Discarded bycatch species was mainly dogfish (12%), with some lobster (0.5%), plus several other species at very low levels (Table 23).

Habitat Impacts

Offshore pollock aggregations are associated with hard bottom topographic features, such as rises, ridges, or mounts, and the location of mobile and fixed gear fisheries are often in close proximity to these features. Some of these are areas of high complexity and high energy (currents generated by tides, wind, and storms). The physical effects on the bottom from pollock fisheries using mobile and fixed gear, and subsequent effects on benthic communities are unknown. While some information exists on the effects of bottom trawl fisheries (DFO 2006), very specific studies would be required to assess the impact of pollock fisheries on benthic communities.

Predator/Prey Interactions

Food Habits

The food habits of pollock were previously described by Carruthers et al. (2005) using data obtained from research surveys on Scotian Shelf during the 1950s and 1960s, and from 1996 to 2002. This work had 3 main findings; first, the increased consumption of fish prey by larger pollock was both temporally and spatially stable. Second, the condition factor of pollock was

decreasing during current time periods. The third, and perhaps the more significant finding, was the temporal change in pollock's primary prey item from krill in the 1950s and 1960s to fish through the 1990s and early 2000s. The decreased abundance of krill as prey coincided with decreases in this prey item across the Shelf as revealed through Continuous Plankton Recorder data (Carruthers et al. 2005).

The diet analysis of Caruthers et al. (2005) was updated using pollock stomach content data that was not previously available from a series of non-standard surveys, as well as new diet information collected from DFO RV surveys conducted from 2003-2008.

Results from the updated analysis confirmed that krill was one of the most important prey items by weight for all size classes of pollock during the pre 1970s, particularly in 4X (Fig. 46). Analysis of stomach content data from the 1996 RV survey showed that krill was replaced by shrimp, amphipods, and fish, as the largest contributors to the diet (Fig. 46). Stomach content data from the 2003 RV survey showed that krill is once again a large component of the diet in 4X (Fig. 46). Similar to the previous work, pollock showed an increase in piscivory with increasing body size across all data sources (Fig. 46). Concurrent with the increases in fish as prey, krill, amphipods, and shrimp showed a decrease in the diet of large pollock.

Seasonal changes in diet were examined for data collected during the pre 1970s as this dataset had the best spatial coverage of the Scotian Shelf/Bay of Fundy. In 4X, diet was stable over the year with krill being a consistently key component of the diet (Fig. 47). In contrast, 4VW shows seasonal changes with krill being important in spring, but during autumn and winter fish are a more important prey item (Fig. 48).

Prey fish of pollock appear to be relatively consistent with silver hake, herring, and sand lance being the largest contributors (Fig. 49). However, regional and season comparisons also show that haddock, lanternfish, and redfish are important components of the diet.

Feeding Behaviour and Condition

Pollock show diel feeding patterns with the highest fullness indices during the early evening (4-8 pm) over summer, autumn, and winter in both the pre 1970s and 1995-2008 RV data (Fig. 50). Spring, however, shows a different pattern of fullness with a peak during the morning hours of 10 am - 12 pm. Spring is also the season with the highest proportion of empty stomachs, which may be due to a post spawning recovery period.

The condition of pollock (as calculated from area specific survey length weight relationships) declined through to the late 1990s in both 4X and 4VW (Fig. 51). However, since then, it has been variable but stable. The main decline occurred during the 1980s. This does not correspond to any observed changes in diet, which occurred later in the 1990s. However, it does correspond to the period when krill were thought to decline (Carruthers et al. 2005).

Predation

Pollock are prey to several species, including cod, white hake, silver hake, and sea raven, and are consumed across their area of distribution (Table 24). None of the predators appear to strongly prefer pollock as prey, as they are never found in more than 0.4% of stomachs examined. Pollock at approximately 15 cm are most commonly observed as prey. It is interesting to note that pollock predation was much higher in 1999 than other sampled years.

SOURCES OF UNCERTAINTY

- Trends in mobile gear catch rates for 2005-2008 appear to be confounded by changes in the fishery and management practices not associated with trends in abundance. Including the CPUE time series as a tuning index improved the model fit, but catch rates since 2004 are not included because they may no longer reflect abundance.
- Pollock, being a semi-pelagic, schooling species, are less well sampled by the summer RV survey than other gadoids. This creates high variability in the RV abundance index from year to year, especially for age 3.
- The VPA results showed high relative error for the current population abundance estimates of ages 3 and 4, and generated low estimates for population abundance at age 2 (recruitment) for 2004 and 2005, which were beyond the range of past model predictions. If the lowest observed level of predicted recruitment for the VPA time series (3.4 million recruits) is used for projections and risk analyses, harvest strategies are more optimistic.
- There is a concern over the lack of summer survey coverage on the Canadian portion of Georges Bank, which is part of the Western Stock Component. Excluding this area from the survey indices could make a difference to the assessment results, if the pollock biomass on Georges Bank was increasing or decreasing more than the biomass in 4X.
- There is uncertainty as to whether the pollock observed in 4Xmn during the summer survey are the same fish captured in the 4W fall test fisheries (although the size and age composition appears to be similar).
- There is a lack of fishery size/age composition data for fixed gear fisheries in the Eastern Component.
- Discarding of small pollock from the 4Xpq redfish fishery may compromise catch at age calculations.
- The level of observer coverage in 4X is far too low to provide meaningful bycatch estimates.

CONCLUSIONS AND ADVICE

Western Component

Using the Base Model formulation, age 4+ population biomass for the Western Component in 2008 is about 27,000 t. The probability of good recruitment is higher when adult biomass is > B_{ref}=30,000 t. Fishing mortality on fully recruited ages 6-9 showed a further decline from 2006 and has been below F_{ref}= 0.2 for the past 2 years. Population age structure appears to be improving at the current level of F (i.e. more older fish are present), but early signs for recruitment of the 2004 and 2005 year classes suggest they may be very weak. The 2002 and 2003 year classes are currently estimated to be about average.

The range of harvest strategies in the 2009/2010 fishing year that are risk averse (25% risk of exceeding F_{ref}) to risk neutral (50% risk of exceeding F_{ref}) are about 3,700 to 4,400 t. If fished at F_{ref}, the projected 2009/2010 2+ catch biomass is 4,100 t, 83% of which will be represented by ages 6-8. At this level of harvest, age 5+ population biomass will continue to decrease from 2009 to 2010.

Alternatively, if recruitment at age 2 for the 2004 and 2005 year classes is not as low as the model estimate and is set to the lowest observed level in the time series (3.4 million), then the range of harvest strategies (risk averse to risk neutral) is about 4,100 to 4,750 t. If fished at F_{ref},

the projected 2009/2010, age 2+ catch biomass is 4,500 t, and at this harvest level, population biomass is expected to stay the same from 2009 to 2010.

These harvest strategies are for 4Xopqrs+5 and would be conservative if applied to all of 4X, since an additional 300-400 t of removals have occurred from 4Xmn over the past 2 years. This risk analyses does not incorporate the uncertainties as noted above and overstates the precision of the estimates of F_{ref} yield outcomes.

Eastern Component

The summer survey biomass index for the Eastern Component has increased since 2006; most of this increase is due to good catches in 4Xmn, but not in 4VW. Pollock from the Eastern Component are smaller in size at age than those from the Western Component, and are represented by proportionally more younger aged fish. Estimates of total mortality from the RV survey indicate a decrease in Z for 2006 and 2007 due to higher abundance in the 2007/2008 surveys; however, it is too early to tell if the situation is actually improving.

The 4W test fishery size composition is similar to what has been observed in past decades, but pollock captured in 2008 were smaller than 2007. These fish were mainly ages 5 and 6 in 2007 and age 4 in 2008. A similar age frequency suggests continuity between 4Xmn and 4W.

Total removals from 4W by all gear sectors was 715 t in 2007 and 514 t in 2008. While the current level of removals has allowed for some rebuilding of the Eastern Component (i.e. in 4Xmn), it is not rebuilt yet (i.e. 4V). Relative F for all Eastern Component fisheries landings/survey biomass) is low at 2.55% and 1.85% for 2007 and 2008, respectively. Therefore, directed pollock fisheries for the east should proceed with caution.

There is a requirement for better sampling of fixed gear and mobile gear catches in 4Xmn and 4W. DFO port sampling for these trips is only available if vessels land west of Shelburne.

Bycatch

With the exception of the 2007/2008 4W test fisheries and, to a lesser extent, 5Z, observer coverage of pollock directed fisheries is very low, and has been implemented largely to address management issues. Notwithstanding these limitations, most of the total catch (82-99%) is landed and counted against respective quotas for these species. Dogfish appears to be the most commonly discarded bycatch species, with other species occurring at low levels.

Pollock are also caught in the small mesh redfish fishery, particularly in Crowell, Jordan, and LaHave basins, and represent 22% of the observed total catch weight for 2006-2008. Based on comparisons of port (dockside) and observer (at-sea) size compositions, pollock < 40 cm may be discarded at-sea.

Bycatch discards may also occur in the 4X pollock gillnet fishery, but observer coverage is far too low (i.e. 2 trips for 2006-2008) to make any conclusions.

Habitat

The habitat over which the directed pollock fishery takes place is highly energetic and of high complexity. The impact of the pollock fishery on the sea floor is currently unknown.

Food and Feeding Habits

The diet of pollock from the Scotian Shelf and Bay of Fundy has shown decadal changes, with euphausiids (krill) being predominant in the diet in the1960s, less so in the 1990s, and once again since 2003.

ACKNOWLEDGEMENTS

We thank the many members of the fishing industry who took time to participate in the process of stock assessment this year. We also thank PED port samplers, G. Donaldson and D. Frotten, for contributing sampling information, and S. Gavaris for suggestions on model formulations. M. Fowler and L. Van Eeckhaute provided helpful editorial comments on an earlier draft of this document.

LITERATURE CITED

Carruthers, E.H., J.D. Neilson, C. Waters, and P. Perley. 2005. Long term changes in the feeding of *Pollachius virens* on the Scotian Shelf: Responses to a dynamic ecosystem. J. Fish. Biol. 66:327-347.

DFO, 2006. Impacts of trawl gears and scallop dredges on benthic habitats, populations and communities. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2006/025. 13p.

Gavaris, S. 1988a. Abundance indices from commercial fishing; pp. 3-13. In D. Rivard (Ed.). Collected papers on stock assessment methods. Can. Atl. Fish. Sci. Advis. Comm. Res. Doc. 88/61. 167 p.

Gavaris, S. 1988b. An adaptive framework for the estimation of population size. Can. Atl. Fish. Sci. Advis. Comm. Res. Doc. 88/29. 12 p.

Gavaris, S. 1980. Use of a multiplicative model to estimate catch rate and effort from commercial data. Can. J. Fish. Aquat. Sci. 37:2272-2275.

Neilson, J.D., and P. Perley. 2005. 2005 assessment of pollock in 4VWX+5Zc. DFO Can. Sci. Advis. Sec. Res. Doc. 2005/074. 57p.

Neilson, J.D., P. Perley, and S. Gavaris. 2004. Pollock stock status in the Canadian Maritimes: A framework assessment. DFO Can. Sci. Advis. Sec. Res. Doc. 2004/040. 48 p.

Rivard, D. 1980. Back-calculating production from cohort analysis, with discussion on surplus production for two redfish stocks. CAFSAC Res. Doc. 80/23: 26 p.

Stone, H.H., P. Perley, and D. Clark. 2006. 2006 assessment of pollock in 4VWX and 5Zc. DFO Can. Sci. Advis. Sec. Res. Doc. 2006/088. 52p.

Walters, C. 2003. Folly and fantasy in the analysis of spatial catch rate data. Can. J. Fish. Aquat. Sci. 60:1433-1436.

Table 1. Landings of pollock by country in 4VWX5. The landings for 2008 represent a partial year (Jan. 1 to Aug. 31).

	Canada	Japan	France	Fed. Rep. Germany	German Dem. Rep.	Cuba	USSR (Russia)	USA	Spain	Other	Total
1974	24975	40		149			2301	435	1500	61	29461
1975	26548			236	95		2004	403	708	124	30118
1976	23565			994	24		1466	443	303	385	27180
1977	24653	1		368			182	325		53	25582
1978	26801	110	33			141	502	451			28038
1979	29967	19	23			50	1025	391		7	31482
1980	35986	81	99			32	950	443			37591
1981	40270	15	90				358	918			41651
1982	38029	3	44			84	297	1107			39564
1983	32749	6	22			261	226	1854			35118
1984	33465	1	46			123	97	2272		1	36005
1985	43300	17	77			66	336	152			43948
1986	43249	51	77			387	564	234		4	44566
1987	45330	82	28			343	314	102			46199
1988	41831	1				225	1054	60			43171
1989	41112	1				99	1782	35			43029
1990	36178					261	1040	213			37692
1991	37931	38				459	1177	68			39673
1992	32002	72	9			1015	1006	57			34161
1993	20253					644	176				21073
1994	15240					10					15250
1995	9781					58					9839
1996	9145					129	6				9280
1997	11927					64					11991
1998	14371					9	1				14381
1999	7738					6					7744
2000	5672										5672
2001	6318										6318
2002	7090										7090
2003	8090										8090
2004	8353										8353
2005	7528										7528
2006	3965										3965
2007	5799										5799
2008	4096										4096

Table 2. Pollock landings (t) by area in the Western Component, (4Xopqrs, 5Yb in Canadian waters, and 5Zc). The landings for 2008 represent a partial year (Jan. 1 to Aug. 31).

	4Xo	4Xp	4Xq	4Xr	4Xs	4Xu	5Yb	5Zc	Total
1982	4781	1499	2675	2508	1345	183	925	4430	18347
1983	4337	1146	3635	1170	461	1319	1079	3301	16448
1984	3536	1189	4541	716	163	1933	2015	1199	15291
1985	6179	595	5718	1284	696	3275	853	911	19511
1986	7326	1073	2531	1046	1287	2066	654	1538	17520
1987	4734	2329	1893	508	1209	2571	1120	2096	16460
1988	3194	3417	3333	307	790	4110	345	2403	17899
1989	3619	3373	2334	332	374	1777	531	1385	13724
1990	3668	2523	2953	1042	693	2629	346	1740	15595
1991	4621	3745	2665	2465	2105	831	456	1715	18602
1992	4174	1528	2626	2175	1793	865	443	3036	16639
1993	2754	1985	2226	1605	941	337	368	4193	14410
1994	1860	1097	1213	1453	866	784	236	3327	10836
1995	429	1158	2552	676	393	683	250	1004	7144
1996	419	1478	1811	686	412	179	256	1200	6441
1997	446	1574	4030	1112	607	447	311	1231	9759
1998	437	3495	3134	564	469	153	425	1857	10534
1999	313	879	1372	648	380	37	135	996	4760
2000	257	1086	1531	264	249	47	136	1197	4768
2001	207	1191	1774	301	186	68	104	1569	5400
2002	201	1482	2628	189	159	52	157	1616	6485
2003	114	1823	2578	403	665	316	594	1347	7839
2004	58	2404	2342	321	557	147	137	2047	8012
2005	126	3397	970	221	324	43	108	1740	6928
2006	99	1187	781	95	290	42	128	848	3469
2007	109	2004	1562	168	133	56	95	552	4679
2008	76	1552	1501	20	18	39	87	330	3623

Table 3. Pollock landings (t) by area in the Eastern Component (4VW+4Xmn). The landings for 2008 represent a partial year (Jan. 1 to Aug. 31).

	4Vn	4Vs	4Vu	4Wd	4We	4Wf	4Wg	4Wh	4Wj	4Wk	4Wl	4Wm	4Wu	4Xm	4Xn	Total
1982	149	2216	162	4	89	8	230	904	3181	1987	2469	25	69	4341	3154	18987
1983	104	5214	13	7	189	24	621	1577	235	1725	702	7	191	2713	2532	15855
1984	351	4598	101	5	60	9	207	1699	252	2061	1406		106	2251	3805	16912
1985	839	9375	7	79	80	6	1002	198	32	1156	247		43	4803	3014	20882
1986	1379	11639	138	202	30	2	658	289	454	986	239		220	4124	2448	22808
1987	915	9680	303	70	26	0	416	92	659	2302	29		154	4947	5987	25583
1988	1448	9307	224	128	85	10	746	124	44	934	841		165	5020	2599	21674
1989	4465	7542		253	79	30	313	253	272	1394	931	6	309	4239	5689	25774
1990	2124	6065		90	20	80	769	160	300	1172	1093	46	350	3078	3886	19233
1991	1043	3009		193	42	7	2146	132	477	1329	2229	106	72	2824	5172	18779
1992	284	2129		149	98	13	990	101	162	1064	2695	44	387	1594	5357	15066
1993	86	743		81	470	1	114	6	5	588	272	1	63	739	2563	5731
1994	437	329		19	434	0	69	11	4	787	60		6	878	1128	4161
1995	397	665		36	3	0	108	31	1	130	188	6	135	220	592	2513
1996	30	432		35	0	0	19	44	0	747	67	1	81	305	898	2660
1997	10	135		7	1	0	1	94	0	606	66	1	73	305	770	2071
1998	155	171		11	16	0	36	63	2	149	1160	1	20	257	1767	3806
1999	29	422		0	0		80	61	1	1067	248	0	3	247	803	2963
2000	6	234		0	0		20	2	0	145	85	0	7	153	239	891
2001	0	94		0	0		7	2	0	128	151	2	15	146	336	882
2002	0	39			0		0	2	0	37	39	0	1	77	317	513
2003	0	4		0	0		1	5	0	15	37	0	4	24	152	243
2004	0	9						2	0	25	135		1	25	144	340
2005	8	4			0		0	1	0	81	75		7	44	379	599
2006	0	15	0	0			0	5	0	67	98		0	42	269	496
2007	0	3	1			10	0	0	1	462	234		8	67	333	1120
2008	0	0					0	1		40	18		1	46	366	473

Table 4. Pollock landings (t) by month in the Western Component, (4Xopqrs, 5Yb in Canadian waters, and 5Zc). The landings for 2008 represent a partial year (Jan. 1 to Aug. 31).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1982	766	667	258	196	1555	2789	3413	2510	2317	2085	1140	620	18317
1983	1147	805	477	495	1814	4650	3272	1659	1207	568	172	77	16344
1984	167	170	362	753	1413	3922	3818	1619	1325	1090	346	91	15076
1985	114	681	841	1892	981	4503	5243	1885	1556	1048	357	222	19323
1986	1023	682	758	452	2221	3015	3678	2649	2069	664	169	23	17404
1987	1428	648	643	34	2212	3686	2797	1905	1431	490	114	836	16224
1988	1043	563	140	375	912	4213	4534	1241	1159	409	151	2561	17301
1989	645	1473	329	459	712	3740	1682	1230	1140	561	1317	320	13607
1990	244	233	44	132	1039	3199	3465	2944	2002	1182	465	923	15874
1991	1091	884	433	1235	1884	3435	3189	2136	1750	1335	729	681	18783
1992	432	625	222	783	1744	2916	3073	2414	1813	1572	817	232	16644
1993	1089	654	633	385	1202	2725	2741	1684	1172	550	900	629	14363
1994	36	244	228	517	801	1931	2950	1350	1061	903	473	489	10981
1995	106	217	206	472	319	2013	1406	255	1472	255	300	180	7200
1996	277	199	222	223	470	786	1226	914	544	606	387	604	6457
1997	56	458	508	681	597	1482	1917	1392	1209	661	560	282	9802
1998	285	624	807	711	953	1872	2193	1109	986	789	165	51	10544
1999	64	59	174	236	348	781	1112	825	666	215	180	111	4771
2000	135	272	301	98	318	738	850	684	553	506	184	140	4778
2001	231	46	417	224	418	775	1180	566	610	534	261	146	5410
2002	139	268	328	415	947	1346	1266	599	505	345	221	121	6501
2003	39	235	941	643	893	1171	1205	901	877	450	374	116	7845
2004	48	514	871	527	676	1806	1547	764	560	367	245	85	8012
2005	398	1065	547	448	536	1460	835	543	371	302	404	19	6928
2006	220	143	344	161	251	533	426	440	283	301	310	57	3469
2007	61	289	654	472	876	502	643	581	367	152	58	19	4675
2008	98	251	388	455	709	577	622	521					3620

Table 5. Pollock landings (t) by gear in the Western Component, (4Xopqrs, 5Yb in Canadian waters, and 5Zc). The landings for 2008 represent a partial year (Jan. 1 to Aug. 31).

	Gillnet	OTB 4+	Longline	Misc	OTB 1-3	Total
1982	2574	6782	2315	241	6435	18347
1983	2416	4307	1618	25	8081	16448
1984	1809	1623	1615	39	10204	15291
1985	3045	1246	2443	52	12725	19511
1986	4378	1928	4447	55	6712	17519
1987	4003	3465	2934	26	6032	16460
1988	3021	5904	1704	93	7177	17899
1989	4217	3558	1391	78	4480	13724
1990	4810	3027	2252	95	5411	15595
1991	3572	3884	2387	132	8627	18602
1992	3784	3135	2789	3	6928	16639
1993	3159	3983	2199	1	5067	14410
1994	2760	1703	2019	44	4310	10836
1995	2620	951	506	4	3062	7144
1996	1301	1733	605	3	2799	6441
1997	2312	1648	978	1	4820	9759
1998	3076	1323	621	21	5492	10534
1999	1431	546	494	5	2286	4761
2000	1796	516	278	5	2172	4768
2001	1776	564	291	1	2765	5398
2002	1621	559	229	1	4074	6484
2003	1902	11	217	9	5699	7839
2004	2017	90	121	1	5782	8012
2005	1356	80	125	0	5365	6926
2006	929	354	87	0	2095	3465
2007	1027	149	180	0	3313	4668
2008	796		92	0	2725	3613

Table 6. Summary of pollock sampling in 2006, 2007, and 2008 (Trimesters 1 and 2) from port (dockside) and observer (at-sea) collections. "Ages" refers to the number of ages used in catch at age calculations.

Year	Number measured/aged			Landings (t)
	Port Samples	Observer Samples	Ages	
2006 (West)	9,557 (42)	17,416 (487)	1111	3,465
2007 (West)	14,249 (66)	5,094 (127)	1649	4,679
2007 (East)	2,008 (8)	8,902 (73)	293	1,120
2008 (WestT1&2)	9,818 (48)	3,540 (82)	1194	3,613
2008 (EastT1&T2)	1,857 (6)	7,740 (8)	264	922

Table 7. Total catch at age (000s) for pollock in the Western Component (4Xopqrs 5Yb in Canadian waters and 5Zc). The catch at age for 2008 includes Jan. 1 to Aug. 31.

	2	3	4	5	6	7	8	9	10	11	12	13
1982	95	1618	1352	371	1031	838	425	145	45	33	13	0
1983	45	1283	3966	854	179	314	291	138	59	17	19	0
1984	4	370	1832	2751	465	85	148	114	41	19	2	0
1985	5	195	621	1806	2142	328	38	100	99	62	30	0
1986	1	162	1410	1136	1329	876	88	37	37	41	15	0
1987	5	104	628	1622	883	786	490	68	17	15	28	0
1988	19	425	990	1126	1281	519	424	242	22	14	20	0
1989	93	386	1533	1129	576	463	147	129	65	6	7	0
1990	47	776	1102	1621	873	429	174	138	49	23	10	0
1991	58	1013	1900	1506	1395	347	157	56	49	25	10	0
1992	46	1250	2678	1651	675	314	124	96	61	14	12	0
1993	4	551	1989	2125	1143	318	92	27	10	7	6	0
1994	51	259	675	1327	1151	494	166	59	14	8	2	0
1995	24	263	537	949	676	294	63	17	4	1	1	0
1996	14	202	949	710	473	256	55	15	0	0	1	0
1997	6	151	900	1654	780	217	54	4	0	1	0	0
1998	7	228	829	1368	1262	307	47	16	2	1	0	0
1999	13	89	496	621	426	173	22	4	1	2	0	0
2000	86	581	404	592	319	139	27	6	1	0	0	0
2001	15	335	814	571	314	91	14	5	2	1	1	0
2002	7	191	787	1073	416	127	20	6	1	0	0	0
2003	2	111	1302	1331	513	120	18	5	1	1	0	0
2004	2	173	542	1876	696	118	13	4	2	1	0	0
2005	0	37	842	759	1160	170	13	5	1	0	0	0
2006	1	30	154	534	353	218	18	3	0	0	0	0
2007	5	68	366	447	622	230	27	3	1	0	0	0
2008	19	86	157	356	388	231	39	8	1	0	0	0

Table 8. Mean weights at age (kg) for pollock from the commercial landings in the Western Component (4Xopqrs+5), 1982-2008. Weights at age for 2008 represent a partial year (Jan. 1 to Aug. 31).

	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12
1982	0.000	0.943	1.427	2.529	3.462	4.211	4.772	5.681	6.239	7.687	8.622	10.621
1983	0.000	0.551	1.349	1.983	3.373	4.367	5.105	5.651	6.624	7.220	8.381	8.886
1984	0.000	0.914	1.635	2.331	3.005	4.078	5.401	6.062	6.208	6.661	7.230	9.725
1985	0.000	0.974	1.615	2.462	3.169	3.695	4.296	6.022	7.315	7.185	7.968	9.343
1986	0.000	0.738	1.554	2.306	3.095	3.929	4.530	5.791	6.651	7.161	7.322	8.698
1987	0.000	0.943	1.475	2.266	3.046	3.564	4.315	4.907	5.300	6.794	7.482	7.909
1988	0.000	1.195	1.549	2.240	3.096	3.807	4.191	4.979	5.886	7.073	8.169	8.454
1989	0.000	0.880	1.313	2.095	3.068	3.885	4.491	4.869	6.012	6.334	8.911	7.133
1990	0.000	0.571	1.263	2.055	2.894	3.657	4.766	5.818	6.371	6.966	7.625	9.770
1991	0.000	0.906	1.344	2.153	2.866	3.736	4.730	5.711	6.460	6.815	8.060	9.030
1992	0.000	1.033	1.271	1.831	2.615	3.509	4.614	5.466	6.141	6.864	8.164	9.189
1993	0.000	0.761	1.110	1.666	2.312	3.143	3.754	4.723	5.492	6.704	7.704	8.131
1994	0.000	0.805	1.250	1.586	2.163	3.058	3.765	4.219	4.854	6.268	6.082	7.846
1995	0.000	0.671	1.132	1.806	2.296	3.038	3.941	4.796	5.389	7.348	8.573	8.781
1996	0.000	0.896	1.336	1.795	2.353	3.057	3.665	5.205	6.296	8.502	9.561	11.422
1997	0.000	0.915	1.388	1.938	2.446	3.288	3.976	5.101	7.763	10.058	6.737	11.915
1998	0.000	0.867	1.103	1.720	2.361	3.144	4.219	5.159	5.640	8.615	8.833	12.063
1999	0.000	0.806	1.193	1.682	2.419	3.245	4.288	5.659	7.057	9.939	9.943	10.000
2000	0.000	0.757	1.247	1.796	2.478	3.166	4.168	5.412	5.745	9.003	9.821	10.000
2001	0.105	0.453	1.039	1.987	2.929	3.734	4.775	6.532	8.118	8.539	9.026	10.788
2002	0.062	0.280	0.931	1.592	2.528	3.714	4.829	6.328	6.936	8.663	10.872	11.081
2003	0.000	0.590	0.977	1.536	2.376	3.528	4.780	6.289	7.427	9.281	10.090	8.875
2004	0.000	0.475	0.873	1.621	2.210	3.125	4.290	6.509	7.369	8.699	9.077	12.027
2005	0.000	0.391	0.955	1.439	2.152	2.801	4.087	5.479	5.956	9.216	14.277	14.277
2006	0.309	0.654	0.931	1.722	2.180	3.101	3.715	4.680	5.186	9.121	9.906	10.851
2007	0.242	0.653	0.943	1.569	2.519	2.965	3.928	4.565	6.282	7.352	10.195	13.091
2008	0.127	0.423	1.184	1.692	2.308	3.258	3.909	4.920	5.572	6.023	9.366	

Table 9. Small mobile gear (TC 1-3) age-disaggregated catch rates (t/hr X 100) for the Western Component (4Xopqrs+5), 1982-2008, calculated using the area-weighting factor. Catch rates for 2008 represent a partial year (Jan. 1 to Aug. 31).

	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8
1982	1.73618	1.05659	0.25010	0.71585	0.63833	0.34690
1983	1.63234	4.79889	0.83825	0.12018	0.19019	0.19183
1984	0.39640	2.20206	3.57016	0.63775	0.11518	0.18886
1985	0.16652	0.59705	1.89335	2.17520	0.31140	0.02630
1986	0.21737	1.60704	1.30413	1.51837	0.97958	0.08333
1987	0.14791	0.88466	1.91960	0.94589	0.83299	0.50974
1988	0.20501	0.58459	0.95114	1.15268	0.42856	0.36128
1989	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
1990	0.85353	1.12637	1.41492	0.62373	0.23423	0.07713
1991	0.60288	1.68167	1.30591	1.03489	0.25098	0.12055
1992	1.06604	2.50417	1.26940	0.33478	0.09245	0.02818
1993	0.47819	1.87069	1.60049	0.59758	0.13088	0.03957
1994	0.27297	0.65252	1.18595	0.94482	0.36754	0.12473
1995	0.70258	1.07739	1.64714	0.95527	0.33871	0.07313
1996	0.51068	2.61485	1.79521	0.89458	0.39270	0.06122
1997	0.21472	1.28138	2.19496	0.77278	0.17993	0.03050
1998	0.15145	0.72029	1.13840	0.89502	0.16216	0.02476
1999	0.08221	0.68238	0.81977	0.45543	0.11994	0.01135
2000	0.95839	0.64343	0.80586	0.33650	0.10960	0.01981
2001	0.57027	1.29688	0.66726	0.30497	0.06890	0.01180
2002	0.22846	1.41125	1.94357	0.59130	0.14948	0.02355
2003	0.17170	2.10031	1.93918	0.54688	0.08971	0.01160
2004	0.24096	0.71439	2.31454	0.64809	0.07471	0.00648
2005	0.04392	1.32878	1.23908	1.58273	0.11223	0.00610
2006	0.03909	0.32913	1.07879	0.48413	0.24977	0.02069
2007	0.18010	1.03520	1.14080	1.49226	0.44718	0.05814
2008	0.17069	0.39796	0.91993	0.86266	0.48596	0.07581

Table 10. DFO summer research vessel survey age-disaggregated numbers per tow for the Western Component, 1984-2008.

	Age3	Age4	Age5	Age6	Age7	Age8
1984	0.545	0.951	3.308	0.913	0.097	0.284
1985	0.101	0.498	2.844	3.613	0.747	0.000
1986	1.468	1.929	1.599	3.027	1.821	0.072
1987	0.064	0.633	1.851	1.119	2.268	1.159
1988	1.651	2.277	6.218	5.278	4.043	1.984
1989	0.098	0.488	1.358	1.957	1.868	0.568
1990	15.197	6.864	10.383	2.456	0.619	0.755
1991	1.872	1.656	2.877	2.862	0.890	0.800
1992	0.364	0.989	1.341	1.061	0.223	0.143
1993	11.941	8.135	4.141	1.815	0.514	0.016
1994	0.301	1.086	2.306	1.980	0.784	0.219
1995	1.501	1.216	1.957	0.986	0.297	0.050
1996	1.142	12.519	10.772	3.475	1.531	0.133
1997	0.351	0.477	1.616	0.763	0.081	0.090
1998	0.126	0.306	0.616	0.609	0.143	0.000
1999	0.538	0.849	0.492	0.378	0.271	0.000
2000	0.480	0.439	0.795	0.216	0.000	0.029
2001	6.976	1.824	0.652	0.177	0.093	0.022
2002	1.583	0.731	0.580	0.200	0.106	0.024
2003	0.904	6.055	2.146	0.491	0.021	0.024
2004	2.462	1.438	3.659	1.347	0.313	0.000
2005	0.082	1.228	1.349	2.412	0.419	0.000
2006	0.896	10.378	22.111	8.642	3.219	0.201
2007	0.068	0.751	3.244	3.763	0.668	0.108
2008	0.210	0.489	4.298	5.222	2.008	0.134

Table 11. Beginning of year population abundance numbers (000's) for pollock in the Western Component from the Base VPA model formulation with 2005-2008 excluded from the CPUE series, using bootstrap bias adjusted population abundance.

Year	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13
1982	16664	20867	4653	1119	2248	1991	947	404	87	102	34	1
1983	9119	13557	15625	2597	583	920	881	396	200	31	54	16
1984	11558	7425	9943	9230	1361	317	472	460	200	111	10	27
1985	7287	9459	5745	6492	5088	697	183	253	274	127	74	6
1986	7818	5962	7569	4144	3694	2250	278	116	118	136	49	34
1987	11224	6400	4735	4928	2372	1834	1057	149	62	63	74	26
1988	8603	9185	5146	3311	2580	1151	799	428	61	35	38	36
1989	12062	7027	7137	3323	1702	970	479	276	135	30	16	13
1990	13888	9791	5404	4465	1708	877	381	260	111	52	19	7
1991	10304	11328	7316	3433	2204	620	335	157	90	47	22	7
1992	5769	8384	8361	4283	1465	568	199	134	78	30	16	9
1993	5556	4682	5738	4444	2029	597	186	54	25	11	12	3
1994	8927	4545	3337	2915	1742	644	206	70	20	11	3	4
1995	6010	7263	3487	2125	1201	407	93	23	6	3	2	1
1996	3958	4899	5709	2371	892	381	75	20	4	2	2	1
1997	3531	3228	3829	3819	1305	309	86	13	3	3	1	1
1998	3356	2886	2506	2326	1648	375	62	23	7	2	1	1
1999	5904	2742	2157	1309	689	240	39	9	4	4	1	1
2000	6749	4822	2164	1319	517	186	44	13	4	2	1	1
2001	10107	5448	3424	1409	551	140	30	12	5	3	2	1
2002	5511	8261	4158	2072	642	172	34	12	6	2	1	1
2003	12351	4506	6591	2696	740	157	29	10	5	4	1	1
2004	7111	10110	3589	4226	1020	153	23	8	4	3	2	1
2005	6295	5820	8121	2450	1784	220	21	8	3	2	1	1
2006	1253	5153	4732	5890	1325	433	31	6	2	2	1	1
2007	1488	1025	4192	3735	4340	767	160	10	2	2	1	1
2008		1214	777	3102	2655	2993	421	106	5	1	1	1

Table 12. Bias adjusted fishing mortality rate for pollock in the Western Component from the Base VPA model formulation.

Year	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	4-9 F	6-9 F	Landings
1982	0.006	0.089	0.383	0.452	0.694	0.616	0.673	0.501	0.834	0.440	0.539	0.000	0.521	0.648	18347
1983	0.005	0.110	0.326	0.446	0.410	0.468	0.449	0.482	0.391	0.942	0.476	0.000	0.358	0.452	16448
1984	0.000	0.057	0.226	0.396	0.469	0.351	0.422	0.318	0.253	0.203	0.285	0.000	0.321	0.419	15291
1985	0.001	0.023	0.127	0.364	0.616	0.718	0.256	0.566	0.504	0.763	0.578	0.000	0.375	0.615	19511
1986	0.000	0.030	0.229	0.358	0.500	0.555	0.423	0.426	0.418	0.408	0.417	0.000	0.359	0.515	17520
1987	0.000	0.018	0.158	0.447	0.523	0.631	0.704	0.693	0.357	0.311	0.529	0.000	0.411	0.600	16460
1988	0.002	0.052	0.237	0.466	0.778	0.676	0.861	0.954	0.501	0.581	0.876	0.000	0.495	0.783	17899
1989	0.009	0.063	0.269	0.465	0.463	0.734	0.410	0.712	0.745	0.249	0.690	0.000	0.386	0.553	13724
1990	0.004	0.091	0.254	0.506	0.813	0.762	0.689	0.863	0.659	0.665	0.785	0.000	0.472	0.789	15595
1991	0.006	0.104	0.335	0.652	1.157	0.935	0.718	0.492	0.888	0.877	0.675	0.000	0.579	1.039	18602
1992	0.009	0.179	0.432	0.547	0.698	0.918	1.113	1.494	1.775	0.737	1.490	0.000	0.528	0.831	16639
1993	0.001	0.139	0.477	0.736	0.947	0.865	0.781	0.799	0.624	1.082	0.786	0.000	0.662	0.916	14410
1994	0.006	0.065	0.251	0.687	1.253	1.734	1.992	2.275	1.530	1.571	0.905	0.000	0.753	1.453	10836
1995	0.004	0.041	0.186	0.668	0.947	1.498	1.323	1.647	1.077	0.415	0.407	0.000	0.542	1.107	7144
1996	0.004	0.046	0.202	0.398	0.859	1.292	1.565	1.604	0.104	0.042	0.438	0.000	0.371	1.029	6441
1997	0.002	0.053	0.298	0.640	1.047	1.412	1.128	0.462	0.132	0.478	0.049	0.000	0.587	1.112	9759
1998	0.002	0.091	0.450	1.017	1.726	2.068	1.674	1.458	0.403	0.475	0.107	0.000	1.045	1.783	10534
1999	0.002	0.036	0.291	0.729	1.109	1.489	0.923	0.647	0.354	0.882	0.000	0.000	0.618	1.190	4760
2000	0.014	0.142	0.229	0.673	1.107	1.623	1.097	0.772	0.285	0.086	0.000	0.000	0.546	1.227	4768
2001	0.002	0.070	0.302	0.585	0.962	1.209	0.692	0.531	0.513	0.331	0.427	0.000	0.465	0.991	5400
2002	0.001	0.026	0.233	0.829	1.208	1.566	0.986	0.730	0.271	0.253	0.185	0.000	0.533	1.264	6485
2003	0.000	0.027	0.245	0.772	1.377	1.705	1.105	0.850	0.305	0.541	0.198	0.000	0.491	1.418	7839
2004	0.000	0.018	0.178	0.662	1.333	1.770	0.900	0.877	0.687	0.669	0.352	0.014	0.565	1.377	8012
2005	0.000	0.006	0.113	0.399	1.208	1.742	1.111	1.024	0.235	0.006	0.007	0.000	0.355	1.264	6928
2006	0.001	0.005	0.032	0.097	0.320	0.768	0.953	0.799	0.094	0.026	0.002	0.000	0.122	0.441	3465
2007	0.002	0.059	0.079	0.119	0.154	0.338	0.191	0.322	0.365	0.200	0.006	0.000	0.131	0.182	4668
2008	0.006	0.052	0.249	0.140	0.196	0.111	0.116	0.118	0.143	0.077	0.000	0.000	0.153	0.148	3613

Table 13. Beginning of year biomass (t) for pollock in the Western Component from the Base VPA formulation using the bootstrap bias adjusted population abundance at the beginning of 2008.

Year	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	2+	3+	4+
1982	4728	16923	7877	3344	8585	8926	4930	2405	602	831	325	11	59487	54758	37835
1983	2765	16745	25936	7659	2268	4265	4574	2426	1345	248	471	175	68878	66113	49368
1984	4163	7010	25999	25196	5046	1539	2625	2725	1328	802	89	271	76793	72630	65620
1985	2353	7630	13219	18824	16953	2918	1042	1686	1830	926	610	63	68054	65701	58071
1986	3308	5364	12167	12995	13035	9204	1389	733	852	983	404	345	60780	57472	52108
1987	2079	4106	8918	12585	7878	7551	4985	827	416	465	562	256	50628	48549	44443
1988	4921	6392	7019	8953	8786	4448	3702	2301	374	264	303	332	47795	42875	36483
1989	4413	5271	13565	8931	5901	4013	2164	1513	824	241	124	125	47084	42672	37401
1990	3524	6426	7148	12430	5722	3773	1949	1450	718	365	180	59	43744	40220	33794
1991	3773	6686	8443	8295	7247	2579	1748	961	593	352	183	75	40935	37162	30476
1992	1907	6503	11489	8525	4646	2357	1014	792	522	226	138	92	38211	36304	29801
1993	2468	2620	6704	9787	5816	2167	867	294	158	79	97	30	31085	28617	25997
1994	2762	3151	3696	4714	4632	2216	819	333	116	69	23	42	22573	19811	16660
1995	1277	3498	4126	4179	3078	1414	396	110	35	26	13	9	18162	16885	13387
1996	792	3005	5949	4626	2363	1273	338	112	25	14	19	10	18524	17732	14727
1997	720	3144	5129	8030	3629	1079	371	81	27	20	14	11	22254	21534	18390
1998	1257	1743	2434	4691	4571	1397	279	122	54	23	12	11	16595	15337	13594
1999	1308	1665	2568	2392	1907	882	190	57	32	33	11	12	11056	9749	8084
2000	1779	3362	2616	2425	1431	684	214	72	32	25	12	10	12662	10884	7521
2001	3164	2860	5065	3314	1677	544	157	80	33	23	19	10	16948	13784	10924
2002	1419	4994	4878	4382	2119	732	188	83	49	23	15	11	18891	17472	12479
2003	2718	3192	7746	5664	2211	662	162	72	39	34	15	11	22526	19807	16615
2004	1459	5724	5131	8054	2780	595	130	54	29	27	19	10	24014	22555	16831
2005	1428	3474	10093	4631	4396	780	101	48	22	17	14	12	25015	23587	20113
2006	439	3616	6589	11342	3343	1383	136	30	17	17	15	13	26939	26501	22885
2007	332	717	6040	8183	11035	2677	658	52	13	16	16	11	29751	29419	28702
2008	2083	937	1043	6112	7607	10191	1851	536	33	10	13	14	30430	28347	27410

Table 14. Beginning of year population abundance numbers (000's) for pollock in the Western Component from the Framework VPA model formulation with 2005-2008 included from the CPUE series, using bootstrap bias adjusted population abundance.

Year	Age 2	Age 3	Age 4	Age5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13
1982	16664	20867	4653	1119	2248	1991	947	404	87	102	34	1
1983	9119	13557	15625	2597	583	920	881	396	200	31	54	16
1984	11558	7425	9943	9230	1361	317	472	460	200	111	10	27
1985	7287	9459	5745	6492	5088	697	183	253	274	127	74	6
1986	7818	5962	7569	4144	3694	2250	278	116	118	136	49	34
1987	11224	6400	4735	4928	2372	1834	1057	149	62	63	74	26
1988	8603	9185	5146	3311	2580	1151	799	428	61	35	38	36
1989	12062	7027	7137	3323	1702	970	479	276	135	30	16	13
1990	13888	9791	5404	4465	1708	877	381	260	111	52	19	7
1991	10304	11328	7316	3433	2204	620	335	157	90	47	22	7
1992	5769	8384	8361	4283	1465	568	199	134	78	30	16	9
1993	5556	4682	5738	4444	2029	597	186	54	25	11	12	3
1994	8927	4545	3337	2915	1742	644	206	70	20	11	3	4
1995	6010	7263	3487	2125	1201	407	93	23	6	3	2	1
1996	3958	4899	5709	2371	892	381	75	20	4	2	2	1
1997	3531	3228	3829	3819	1305	309	86	13	3	3	1	1
1998	3356	2886	2506	2326	1648	375	62	23	7	2	1	1
1999	5904	2742	2157	1309	689	240	39	9	4	4	1	1
2000	6743	4822	2164	1319	517	186	44	13	4	2	1	1
2001	10022	5443	3424	1409	551	140	30	12	5	3	2	1
2002	5236	8191	4154	2072	642	172	34	12	6	2	1	1
2003	10830	4281	6534	2693	740	157	29	10	5	4	1	1
2004	4626	8865	3404	4179	1018	153	23	8	4	3	2	1
2005	4283	3785	7102	2299	1746	218	21	8	3	2	1	1
2006	1838	3506	3066	5055	1202	403	30	6	2	2	1	1
2007	2336	1504	2844	2372	3657	667	135	8	2	2	1	1
2008		1908	1170	1998	1539	2434	339	86	4	1	1	1

Table 15. Bias adjusted fishing mortality rate for pollock in the Western Component from the Framework VPA model formulation with 2005-2008 included from the CPUE series.

Year	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	4-9 F	6-9 F	Landings
1982	0.006	0.089	0.383	0.452	0.694	0.616	0.673	0.501	0.834	0.440	0.539	0.000	0.521	0.648	18347
1983	0.005	0.110	0.326	0.446	0.410	0.468	0.449	0.482	0.391	0.942	0.476	0.000	0.358	0.452	16448
1984	0.000	0.057	0.226	0.396	0.469	0.351	0.422	0.318	0.253	0.203	0.285	0.000	0.321	0.419	15291
1985	0.001	0.023	0.127	0.364	0.616	0.718	0.256	0.566	0.504	0.763	0.578	0.000	0.375	0.615	19511
1986	0.000	0.030	0.229	0.358	0.500	0.555	0.423	0.426	0.418	0.408	0.417	0.000	0.359	0.515	17520
1987	0.000	0.018	0.158	0.447	0.523	0.631	0.704	0.693	0.357	0.311	0.529	0.000	0.411	0.600	16460
1988	0.002	0.052	0.237	0.466	0.778	0.676	0.861	0.954	0.501	0.581	0.876	0.000	0.495	0.783	17899
1989	0.009	0.063	0.269	0.465	0.463	0.734	0.410	0.712	0.745	0.249	0.690	0.000	0.386	0.553	13724
1990	0.004	0.091	0.254	0.506	0.813	0.762	0.689	0.863	0.659	0.665	0.785	0.000	0.472	0.789	15595
1991	0.006	0.104	0.335	0.652	1.157	0.935	0.718	0.492	0.888	0.877	0.675	0.000	0.579	1.039	18602
1992	0.009	0.179	0.432	0.547	0.698	0.918	1.113	1.494	1.775	0.737	1.490	0.000	0.528	0.831	16639
1993	0.001	0.139	0.477	0.736	0.947	0.865	0.781	0.799	0.624	1.082	0.786	0.000	0.662	0.916	14410
1994	0.006	0.065	0.251	0.687	1.253	1.734	1.992	2.275	1.530	1.571	0.905	0.000	0.753	1.453	10836
1995	0.004	0.041	0.186	0.668	0.947	1.498	1.323	1.647	1.077	0.415	0.407	0.000	0.542	1.107	7144
1996	0.004	0.046	0.202	0.398	0.859	1.292	1.565	1.604	0.104	0.042	0.438	0.000	0.371	1.029	6441
1997	0.002	0.053	0.298	0.640	1.047	1.412	1.128	0.462	0.132	0.478	0.049	0.000	0.587	1.112	9759
1998	0.002	0.091	0.450	1.017	1.726	2.068	1.674	1.458	0.403	0.475	0.107	0.000	1.045	1.783	10534
1999	0.002	0.036	0.291	0.729	1.109	1.489	0.923	0.647	0.354	0.882	0.000	0.000	0.618	1.190	4760
2000	0.014	0.142	0.229	0.673	1.107	1.623	1.097	0.772	0.285	0.086	0.000	0.000	0.546	1.227	4768
2001	0.002	0.070	0.302	0.585	0.962	1.209	0.692	0.531	0.513	0.331	0.427	0.000	0.465	0.991	5400
2002	0.002	0.026	0.233	0.829	1.208	1.566	0.986	0.730	0.271	0.253	0.185	0.000	0.533	1.264	6485
2003	0.000	0.029	0.247	0.773	1.377	1.705	1.105	0.850	0.305	0.541	0.198	0.000	0.494	1.418	7839
2004	0.000	0.021	0.190	0.673	1.340	1.770	0.900	0.877	0.687	0.669	0.352	0.014	0.583	1.383	8012
2005	0.000	0.010	0.133	0.439	1.262	1.789	1.111	1.024	0.235	0.006	0.007	0.000	0.402	1.317	6928
2006	0.000	0.008	0.052	0.116	0.371	0.867	1.059	0.799	0.094	0.026	0.002	0.000	0.162	0.507	3465
2007	0.002	0.043	0.135	0.208	0.190	0.425	0.234	0.401	0.365	0.200	0.006	0.000	0.195	0.227	4668
2008	0.006	0.046	0.181	0.260	0.380	0.142	0.159	0.150	0.192	0.077	0	0	0.228	0.227	3613

Table 16. Beginning of year biomass (t) for pollock in the Western Component from the Framework VPA model formulation with 2005-2008 included from the CPUE series, using the bootstrap bias adjusted population abundance at the beginning of 2008.

Year	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	2+	3+	4+
1982	4728	16923	7877	3344	8585	8926	4930	2405	602	831	325	11	59487	54758	37835
1983	2765	16745	25936	7659	2268	4265	4574	2426	1345	248	471	175	68878	66113	49368
1984	4163	7010	25999	25196	5046	1539	2625	2725	1328	802	89	271	76793	72630	65620
1985	2353	7630	13219	18824	16953	2918	1042	1686	1830	926	610	63	68054	65701	58071
1986	3308	5364	12167	12995	13035	9204	1389	733	852	983	404	345	60780	57472	52108
1987	2079	4106	8918	12585	7878	7551	4985	827	416	465	562	256	50628	48549	44443
1988	4921	6392	7019	8953	8786	4448	3702	2301	374	264	303	332	47795	42875	36483
1989	4413	5271	13565	8931	5901	4013	2164	1513	824	241	124	125	47084	42672	37401
1990	3524	6426	7148	12430	5722	3773	1949	1450	718	365	180	59	43744	40220	33794
1991	3773	6686	8443	8295	7247	2579	1748	961	593	352	183	75	40935	37162	30476
1992	1907	6503	11489	8525	4646	2357	1014	792	522	226	138	92	38211	36304	29801
1993	2468	2620	6704	9787	5816	2167	867	294	158	79	97	30	31085	28617	25997
1994	2762	3151	3696	4714	4632	2216	819	333	116	69	23	42	22573	19811	16660
1995	1277	3498	4126	4179	3078	1414	396	110	35	26	13	9	18162	16885	13387
1996	792	3005	5949	4626	2363	1273	338	112	25	14	19	10	18524	17732	14727
1997	720	3144	5129	8030	3629	1079	371	81	27	20	14	11	22254	21534	18390
1998	1257	1743	2434	4691	4571	1397	279	122	54	23	12	11	16595	15337	13594
1999	1308	1665	2568	2392	1907	882	190	57	32	33	11	12	11056	9749	8084
2000	1777	3362	2616	2425	1431	684	214	72	32	25	12	10	12661	10884	7521
2001	3137	2858	5065	3314	1677	544	157	80	33	23	19	10	16919	13782	10924
2002	1348	4952	4873	4382	2119	732	188	83	49	23	15	11	18774	17426	12474
2003	2384	3032	7679	5657	2211	662	162	72	39	34	15	11	21957	19574	16542
2004	949	5019	4868	7965	2773	595	130	54	29	27	19	10	22439	21490	16471
2005	972	2260	8826	4346	4303	773	101	48	22	17	14	12	21691	20719	18460
2006	644	2460	4270	9734	3033	1287	129	30	17	17	15	13	21647	21003	18543
2007	521	1053	4097	5195	9298	2326	558	45	13	16	16	11	23150	22628	21575
2008	2083	1473	1570	3937	4410	8288	1491	435	27	10	13	14	23749	21666	20194

Table 17. Bias adjusted statistical properties of estimates for population abundance and survey calibration constants for pollock in the Western Component using the Base VPA model formulation.

		Bootstrap			
Age	Estimate	Standard Error	Relative Error	Bias	Relative Bias
Population Abundance					
3	1490	2629.071	1.765	508.457	0.341
4	653	541.956	0.830	120.051	0.184
5	2686	1889.991	0.704	305.659	0.114
6	2184	1266.327	0.580	223.894	0.103
7	2557	1075.138	0.420	155.701	0.061
8	365	212.140	0.581	33.861	0.093
RV Survey Calibration Constants					
1984-2008 (Ages 3-8)					
3	0.00013	0.00002	0.16807	0.00000	0.01297
4	0.00038	0.00006	0.16248	0.00001	0.01445
5	0.00101	0.00017	0.16372	0.00001	0.00814
6	0.00156	0.00025	0.16011	0.00002	0.01381
7	0.00179	0.00028	0.15843	0.00003	0.01440
8	0.00147	0.00026	0.17909	0.00002	0.01605
CPUE Calibration Constants					
1982-2004 (Ages 3-8)					
3	0.00000	0.00037	317.96456	0.00005	43.88887
4	0.00001	0.00191	227.03467	0.00027	31.80909
5	0.00009	0.00694	80.61210	0.00087	10.10988
6	0.00013	0.00156	12.37105	0.00032	2.55824
7	0.00008	0.00014	1.69131	0.00004	0.52339
8	0.00001	0.00001	0.79444	0.00000	0.15975
CPUE Power Coefficients					
1982-2004 (Ages 3-8)					
3	0.93254	0.33902	0.36354	-0.00562	-0.00603
4	0.88259	0.33401	0.37844	-0.01243	-0.01408
5	0.66181	0.27977	0.42274	-0.00208	-0.00314
6	0.59663	0.23519	0.39420	-0.00056	-0.00093
7	0.58581	0.16105	0.27492	-0.00057	-0.00098
8	0.81583	0.12645	0.15500	0.00452	0.00554

Table 18. Deterministic projection results for pollock in the Western Component from the Base VPA formulation using the bootstrap bias adjusted population abundance at the beginning of 2008.

Projected Population Numbers

	2	3	4	5	6	7	8	9	10	11	12	13
2008.67	4355	981	533	2380	1960	2402	331	85	4	1	1	1
2009.25	5000	3872	860	462	2030	1634	1984	275	70	4	1	1
2010.25	5000	4077	3036	656	337	1394	1095	1344	184	49	3	1

Fishing Mortality

	2	3	4	5	6	7	8	9	10	11	12	13
2008.67	0.003	0.028	0.045	0.075	0.114	0.129	0.123	0.132	0.108	0.057	0.001	0.000
2009.25	0.004	0.043	0.070	0.115	0.176	0.200	0.190	0.203	0.166	0.087	0.001	0.000

PR

	2	3	4	5	6	7	8	9	10	11	12	13
2008.67	0.02	0.22	0.35	0.58	0.88	1.00	0.95	1.02	0.83	0.44	0.01	0.00
2009.25	0.02	0.22	0.35	0.58	0.88	1.00	0.95	1.02	0.83	0.44	0.01	0.00

BegWt

	2	3	4	5	6	7	8	9	10	11	12	13
2008.67	0.33	0.72	1.39	2.03	2.64	3.36	4.28	5.22	6.52	9.10	11.61	11.65
2009.25	0.33	0.72	1.39	2.03	2.64	3.36	4.28	5.22	6.52	9.10	11.61	11.65
2010.25	0.33	0.72	1.39	2.03	2.64	3.36	4.28	5.22	6.52	9.10	11.61	11.65

Projected Population Biomass

	2	3	4	5	6	7	8	9	10	11	12	13	2+	3+	4+	5+
2008.67	1437	711	742	4830	5183	8077	1419	444	27	9	12	12	22903	21466	20755	20013
2009.25	1650	2803	1197	938	5367	5496	8497	1435	458	32	10	10	27893	26243	23440	22243
2010.25	1650	2952	4226	1332	891	4689	4692	7015	1198	443	31	8	29126	27476	24524	20298

Projected Catch Numbers

	2	3	4	5	6	7	8	9	10	11	12	13
2008.67	6	15	13	95	118	164	22	6	0	0	0	0
2009.25	18	149	53	46	297	269	312	46	10	0	0	0

AvgWt

	2	3	4	5	6	7	8	9	10	11	12	13
2008.67	0.58	1.02	1.66	2.34	3.11	3.85	4.72	5.68	7.50	9.82	11.82	11.00
2009.25	0.58	1.02	1.66	2.34	3.11	3.85	4.72	5.68	7.50	9.82	11.82	11.00

Projected Catch Biomass

	2	3	4	5	6	7	8	9	10	11	12	13	2+	3+	4+	5+
2008.67	4	15	22	223	367	632	102	34	2	0	0	0	1400	1396	1381	1359
2009.25	10	152	88	107	924	1037	1471	261	73	3	0	0	4126	4116	3964	3876

Table 19. Kept versus discarded bycatch reported for 2006-2008 combined observed trips in 4X from pollock-directed mobile gear trips.

Species	Total Kept (t)	Total Discarded (t)	% Kept	% Discarded
POLLOCK	172.099	0.000	92.20	0.00
HADDOCK	2.965	0.000	1.59	0.00
COD(ATLANTIC)	2.333	0.000	1.25	0.00
WHITE HAKE	0.450	0.000	0.24	0.00
REDFISH	0.481	0.005	0.26	0.00
WINTER FLOUNDER	0.052	0.000	0.03	0.00
MONKFISH	0.047	0.000	0.03	0.00
WITCH FLOUNDER	0.030	0.000	0.02	0.00
CUSK	0.020	0.000	0.01	0.00
AMERICAN PLAICE	0.005	0.000	0.00	0.00
AMERICAN LOBSTER	0.000	0.532	0.00	0.29
SPINY DOGFISH	0.000	3.584	0.00	1.92
THORNY SKATE	0.000	0.059	0.00	0.03
LONGHORN SCULPIN	0.000	0.001	0.00	0.00
ASTEROIDEA	0.000	0.001	0.00	0.00
STRIPED ATLANTIC WOLFFISH	0.005	0.000	0.00	0.00
UNIDENTIFIED SKATES	0.000	0.035	0.00	0.02
SHAD AMERICAN	0.042	0.175	0.02	0.09
LITTLE SKATE	0.000	0.001	0.00	0.00
HALIBUT	0.027	0.000	0.01	0.00
BASKING SHARK	0.000	3.629	0.00	1.94
BARNDOOR SKATE	0.000	0.081	0.00	0.04
TOTAL	***178.556***	***8.103***	***95.66***	***4.34***

Table 20. Kept versus discarded bycatch reported for 2006-2008 combined observed trips in 5Z from pollock-directed mobile gear trips.

Species	Total Kept (t)	Total Discarded (t)	% Kept	% Discarded
POLLOCK	238.458	0.010	90.65	0.00
HADDOCK	19.151	0.001	7.28	0.00
COD	2.936	0.000	1.12	0.00
REDFISH	0.157	0.000	0.06	0.00
YELLOWTAIL FLOUNDER	0.045	0.000	0.02	0.00
STRIPED ATLANTIC WOLFFISH	0.070	0.000	0.03	0.00
AMERICAN PLAICE	0.013	0.001	0.00	0.00
MONKFISH	0.008	0.000	0.00	0.00
WHITE HAKE	0.004	0.000	0.00	0.00
WINTER FLOUNDER	0.003	0.000	0.00	0.00
THORNY SKATE	0.002	0.053	0.00	0.02
SPINY DOGFISH	0.000	1.927	0.00	0.73
AMERICAN LOBSTER	0.000	0.113	0.00	0.04
BARNDOOR SKATE	0.000	0.055	0.00	0.02
WINTER SKATE	0.000	0.038	0.00	0.01
SEA RAVEN	0.000	0.009	0.00	0.00
SHORT-FIN SQUID	0.000	0.003	0.00	0.00
LONGHORN SCULPIN	0.000	0.002	0.00	0.00
UNIDENTIFIED SKATES)	0.000	0.002	0.00	0.00
TOTAL	***260.847***	***2.214***	***99.16***	***0.84***

Table 21. Kept versus discarded bycatch reported for 2007-2008 combined observed trips in 4W test fisheries from pollock-directed mobile gear trips.

Species	Total Kept (t)	Total Discarded (t)	% Kept	% Discarded
POLLOCK	664.898	0.272	97.52	0.04
REDFISH	5.991	0.126	0.88	0.02
COD	1.044	0.002	0.15	0.00
HADDOCK	1.026	0.001	0.15	0.00
WHITE HAKE	0.687	0.073	0.10	0.01
WITCH FLOUNDER	0.110	0.082	0.02	0.01
MONKFISH	0.095	0.001	0.01	0.00
CUSK	0.048	0.010	0.01	0.00
HALIBUT	0.037	0.085	0.01	0.01
STRIPED ATLANTIC WOLFFISH	0.011	0.000	0.00	0.00
RED HAKE	0.004	0.000	0.00	0.00
AMERICAN PLAICE	0.005	0.000	0.00	0.00
SPONGES	0.000	6.107	0.00	0.90
UNIDENTIFIED SEALS	0.000	0.454	0.00	0.07
ATLANTIC TORPEDO	0.000	0.215	0.00	0.03
LITTLE SKATE	0.000	0.036	0.00	0.01
AMERICAN LOBSTER	0.000	0.133	0.00	0.02
THORNY SKATE	0.000	0.018	0.00	0.00
BARNDOOR SKATE	0.010	0.084	0.00	0.01
SHAD AMERICAN	0.000	0.004	0.00	0.00
WINTER SKATE	0.000	0.002	0.00	0.00
SHORT-FIN SQUID	0.000	0.026	0.00	0.00
SPINY DOGFISH	0.000	0.007	0.00	0.00
SPIDER CRAB	0.000	0.001	0.00	0.00
LUMPFISH	0.000	0.001	0.00	0.00
TURBOT	0.002	0.000	0.00	0.00
SWORDFISH	0.000	0.102	0.00	0.01
SILVER HAKE	0.001	0.001	0.00	0.00
LONGHORN SCULPIN	0.000	0.002	0.00	0.00
UNIDENTIFIED HAKE	0.005	0.000	0.00	0.00
FOURSPOT FLOUNDER	0.001	0.000	0.00	0.00
LARGE-EYED ARGENTINE	0.001	0.000	0.00	0.00
TOTAL	***673.976***	***7.845***	***98.85***	***1.15***

Table 22. Kept versus discarded bycatch reported for 2008 in 4X from observed pollock-directed gillnet trips.

Species	Total Kept (t)	Total Discarded (t)	% Kept	% Discarded
POLLOCK	13.669	0.165	61.15	0.74
WHITE HAKE	3.263	0.222	14.60	0.99
COD	0.978	0.054	4.38	0.24
SHORTFIN MAKO	0.324	0.000	1.45	0.00
THRESHER SHARK	0.136	0.000	0.61	0.00
MONKFISH	0.016	0.000	0.07	0.00
REDFISH	0.011	0.000	0.05	0.00
CUSK	0.011	0.000	0.05	0.00
HADDOCK	0.009	0.000	0.04	0.00
BASKING SHARK	0.000	3.182	0.00	14.24
SPINY DOGFISH	0.000	0.168	0.00	0.75
SHAD AMERICAN	0.000	0.085	0.00	0.38
BLUE SHARK	0.000	0.034	0.00	0.15
HERMIT CRABS	0.000	0.011	0.00	0.05
THORNY SKATE	0.000	0.007	0.00	0.03
AMERICAN LOBSTER	0.000	0.005	0.00	0.02
SILVER HAKE	0.000	0.001	0.00	0.00
HERRING	0.000	0.001	0.00	0.00
TOTAL	***18.417***	***3.935***	***82.40***	***17.60***

Table 23. Kept versus discarded bycatch reported for 2006-2008 combined observed trips in 4X from redfish-directed mobile gear trips.

Species	Total Kept (t)	Total Discarded (t)	% Kept	% Discarded
REDFISH	280.024	0.045	58.42	0.01
POLLOCK	106.457	0.000	22.21	0.00
HADDOCK	14.075	0.000	2.94	0.00
WHITE HAKE	4.672	0.000	0.97	0.00
COD(ATLANTIC)	5.870	0.000	1.22	0.00
MONKFISH	0.484	0.000	0.10	0.00
CUSK	0.538	0.000	0.11	0.00
WITCH FLOUNDER	1.021	0.000	0.21	0.00
BARNDOOR SKATE	0.119	0.488	0.02	0.10
BLACK BELLY ROSEFISH	0.551	0.003	0.11	0.00
STRIPED ATLANTIC WOLFFISH	0.111	0.009	0.02	0.00
SMOOTH SKATE	0.040	0.032	0.01	0.01
AMERICAN LOBSTER	0.031	2.257	0.01	0.47
RED HAKE	0.176	0.000	0.04	0.00
HALIBUT	0.231	0.128	0.05	0.03
SILVER HAKE	0.728	0.042	0.15	0.01
WINTER SKATE	0.019	0.160	0.00	0.03
AMERICAN PLAICE	0.098	0.000	0.02	0.00
THORNY SKATE	0.008	0.261	0.00	0.05
WINTER FLOUNDER	0.024	0.000	0.01	0.00
SUMMER FLOUNDER	0.002	0.000	0.00	0.00
MACKEREL	0.001	0.091	0.00	0.02
TURBOT	0.001	0.000	0.00	0.00
UNIDENTIFIED GRENADIERS	0.001	0.000	0.00	0.00
SPINY DOGFISH	0.000	57.595	0.00	12.02
STONES AND ROCKS	0.000	0.712	0.00	0.15
BLACK DOGFISH	0.000	0.455	0.00	0.09
SHAD AMERICAN	0.000	0.573	0.00	0.12
LARGE-EYED ARGENTINE	0.000	0.058	0.00	0.01
SCULPINS	0.000	0.026	0.00	0.01
WHITE SKATE	0.000	0.017	0.00	0.00
LUMPFISH	0.010	0.027	0.00	0.01
ALEWIFE	0.000	0.551	0.00	0.11
LITTLE SKATE	0.000	0.083	0.00	0.02
HERRING	0.000	0.117	0.00	0.02
UNIDENTIFIED ARGENTINES	0.000	0.006	0.00	0.00
SHORT-FIN SQUID	0.000	0.005	0.00	0.00
AMERICAN JOHN DORY	0.000	0.003	0.00	0.00
SEA RAVEN	0.027	0.014	0.01	0.00
SPONGES	0.000	0.030	0.00	0.01
UNIDENTIFIED SCULPIN	0.000	0.001	0.00	0.00
NORTHERN STONE CRAB	0.000	0.001	0.00	0.00
JELLYFISHES	0.000	0.005	0.00	0.00
ATLANTIC ROCK CRAB	0.000	0.001	0.00	0.00
YELLOWTAIL FLOUNDER	0.008	0.000	0.00	0.00
UNIDENTIFIED SKATES	0.000	0.136	0.00	0.03
PORCUPINE CRAB	0.000	0.001	0.00	0.00
LONGHORN SCULPIN	0.024	0.004	0.01	0.00
EYED FLOUNDER	0.011	0.000	0.00	0.00
BUTTERFISH	0.000	0.005	0.00	0.00
ASTEROIDEA	0.000	0.002	0.00	0.00
ATLANTIC ARGENTINE	0.005	0.002	0.00	0.00
TOTAL	***415.367***	***63.946***	***86.66***	***13.34***

Table 24. Observed predation on pollock based on stomach content data of various fish species collected from DFO RV surveys.

Predator	Instances of Pollock Consumed	Number of Stomachs Examined	Proportion
Atlantic cod	19	30778	<0.001
Haddock	1	36599	<0.001
White hake	12	3926	0.003
Red hake	1	647	0.001
Silver hake	5	6477	<0.001
Pollock	7	4519	0.002
Atlantic halibut	1	1222	<0.001
Greenland halibut	1	1165	<0.001
Winter skate	1	715	0.001
Spiny dogfish	1	1243	<0.001
Longhorn sculpin	2	2025	<0.001
Sea raven	3	750	0.004
Monkfish	2	664	0.003

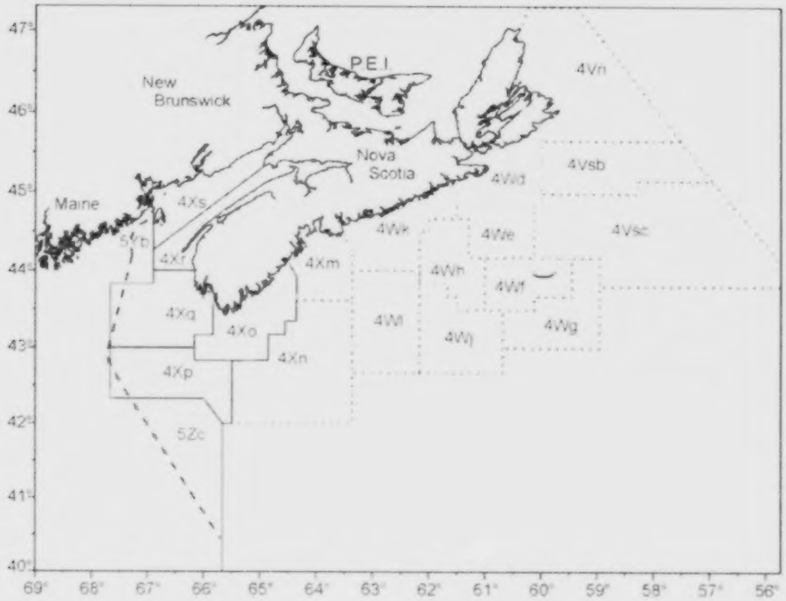


Fig. 1. DFO Statistical Unit Areas for the Scotian Shelf, Bay of Fundy, and eastern Georges Bank. Areas forming the Western Component of pollock on the Scotian Shelf, Bay of Fundy, and Georges Bank are outlined as solid lines, and those comprising the Eastern Component are shown dashed lines.

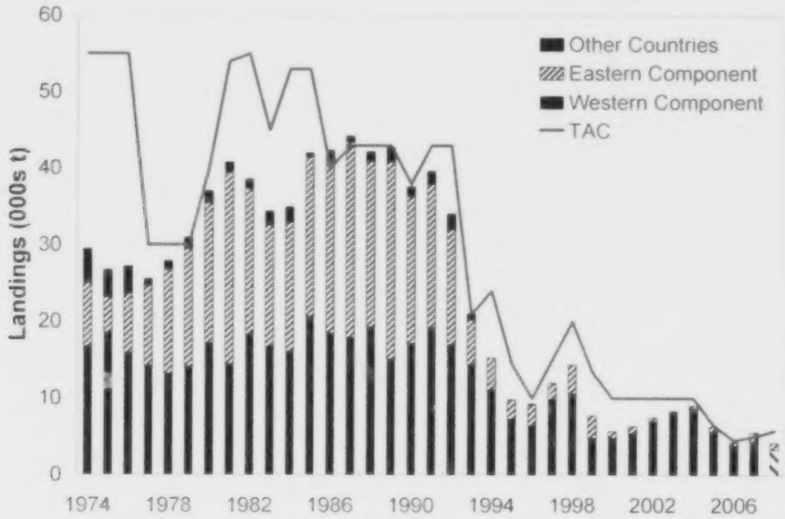


Fig. 2. Landings of 4VWX5 pollock, shown with respect to the Total Allowable Catch (TAC). The striped bar in 2008 signifies incomplete landings. Prior to 1999, the quota year was Jan. 1 to Dec. 31. In 1999, the quota year was Jan. 1, 1999 to Mar. 31, 2000. Subsequently, it is Apr 1 to Mar. 31. All landings are shown for quota years. (2005-2007 TAC is for 4X only).

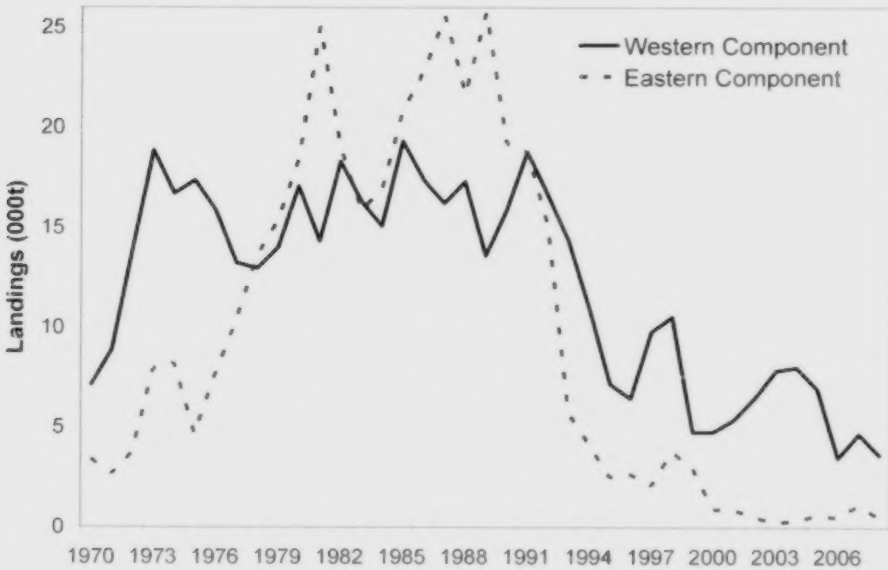


Fig. 3. Calendar year landings of pollock from the Eastern and Western components, 1970-2008. Landings for 2008 are from Jan. - Aug.

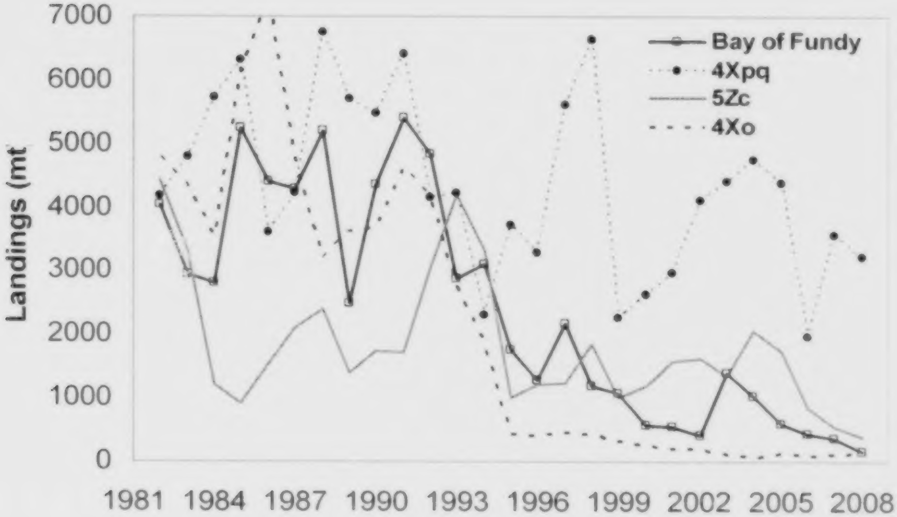


Fig. 4. Calendar year landings of pollock for the Western Component by statistical Unit Area, 1982-2008. Landings for 2008 are from Jan.-Aug.

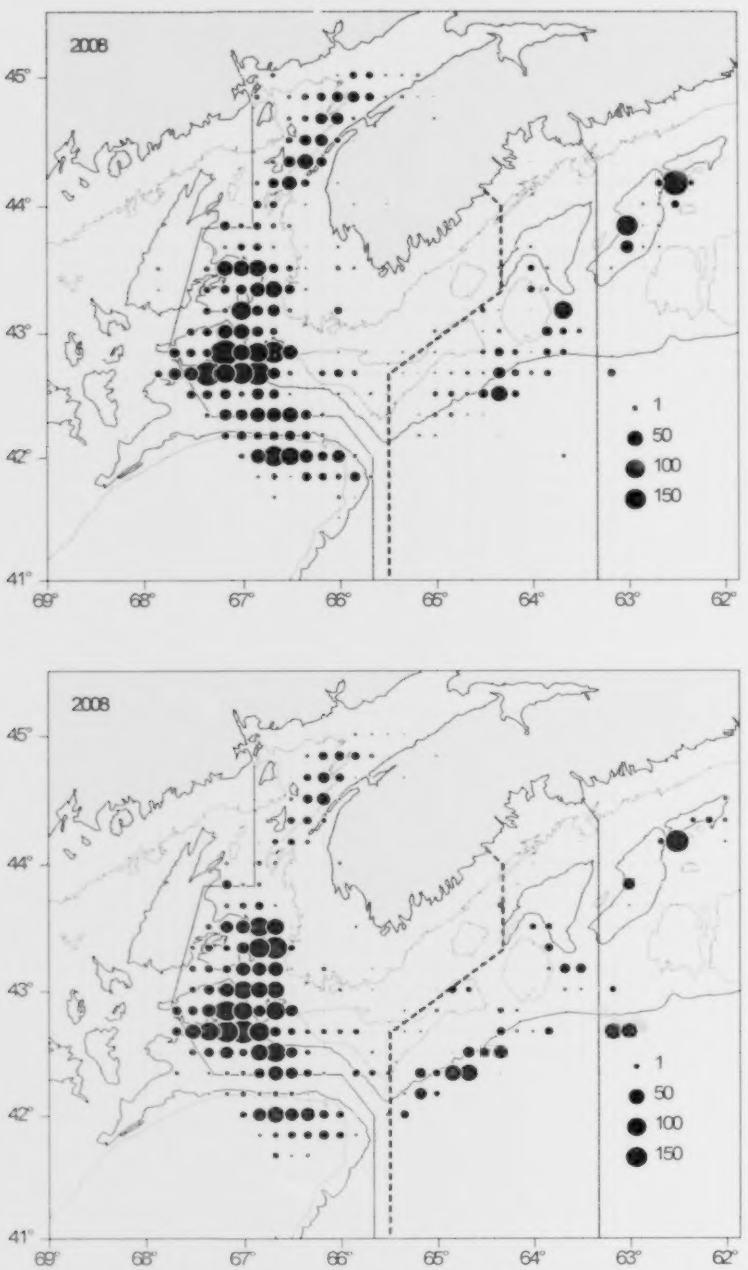


Fig. 5. Spatial distribution of pollock mobile gear catches in 2007 (upper panel) and 2008 (lower panel) by 10 minute squares. Data for 2008 is from Jan-Dec. Dashed line separates Western and Eastern Components.

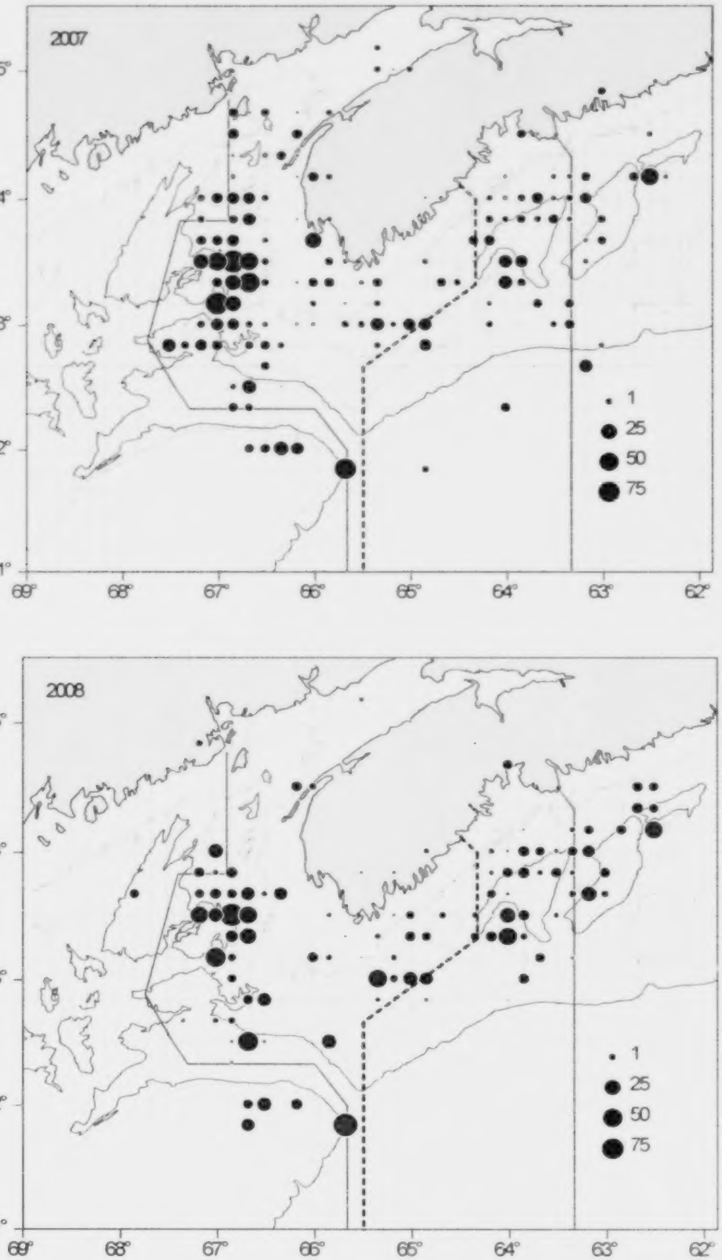


Fig. 6. Spatial distribution of pollock gillnet catches in 2007 (upper panel) and 2008 (lower panel) by 10 minute squares. Data for 2008 is from Jan.-Dec. Dashed line separates Western and Eastern components.

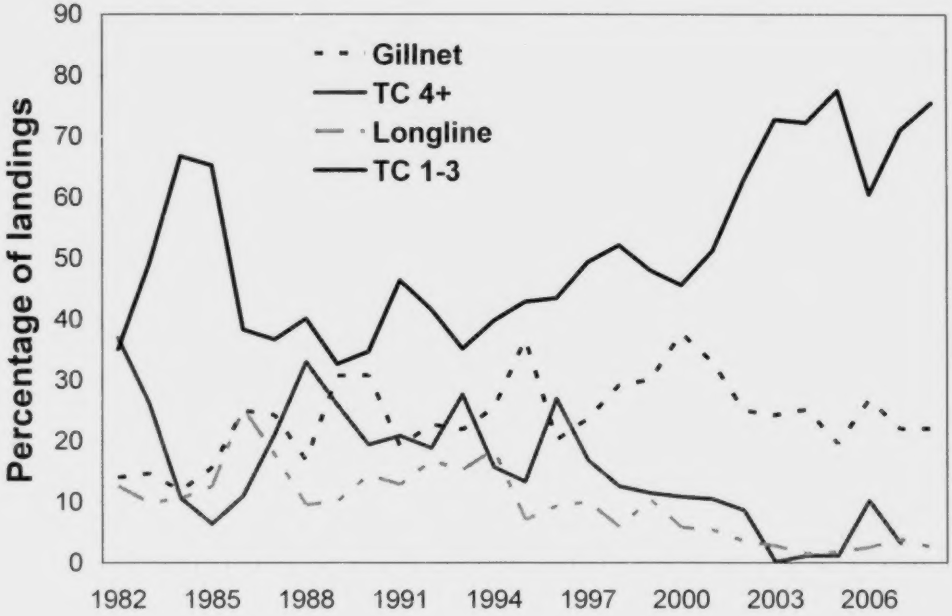


Fig. 7. Percentage of pollock landings by gear type for the Western Component, 1982-2008.

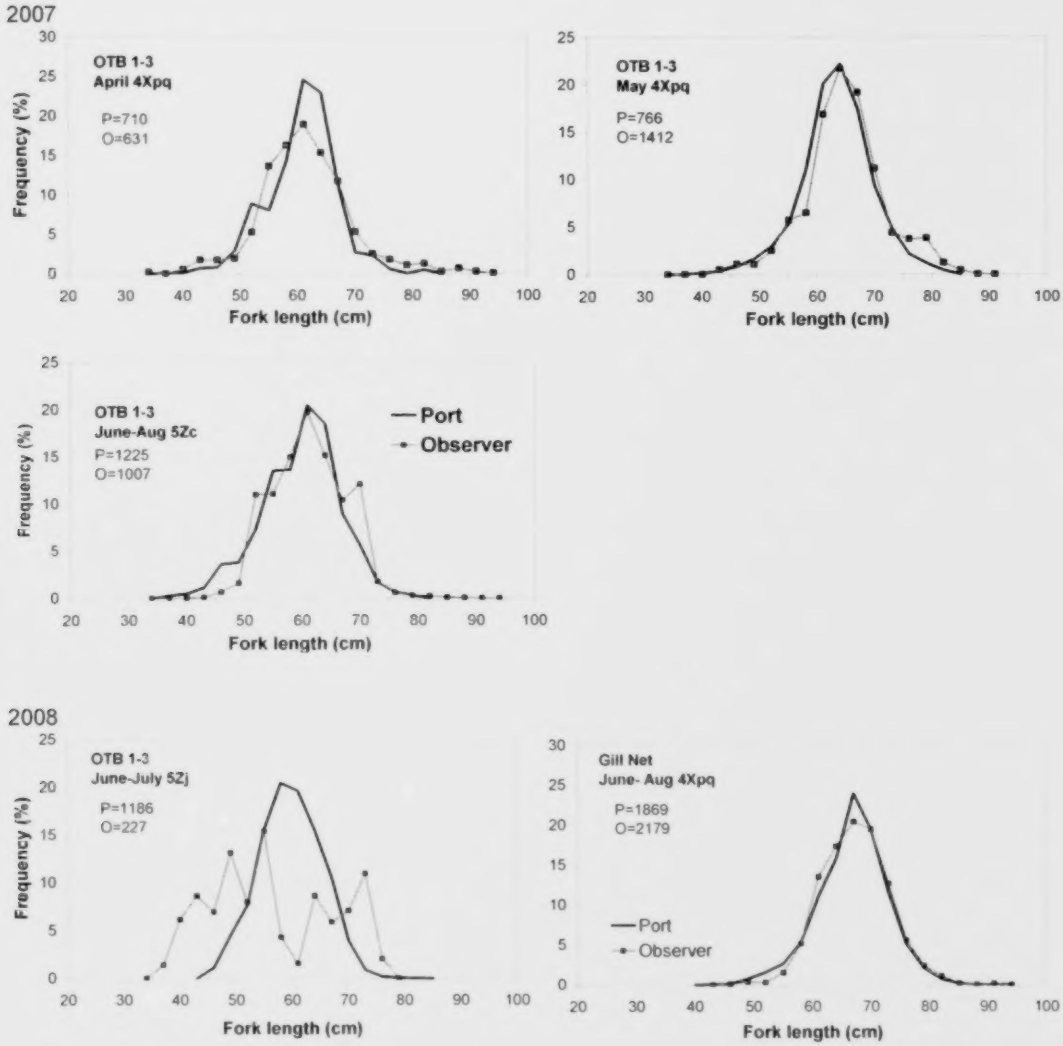


Fig. 8. Comparisons of 2008 port (dockside) and observer (at-sea) sample length measurements of pollock from the directed fishery, 2007 and 2008. Number of fish measured is shown for port (P) and observer (O) samples.

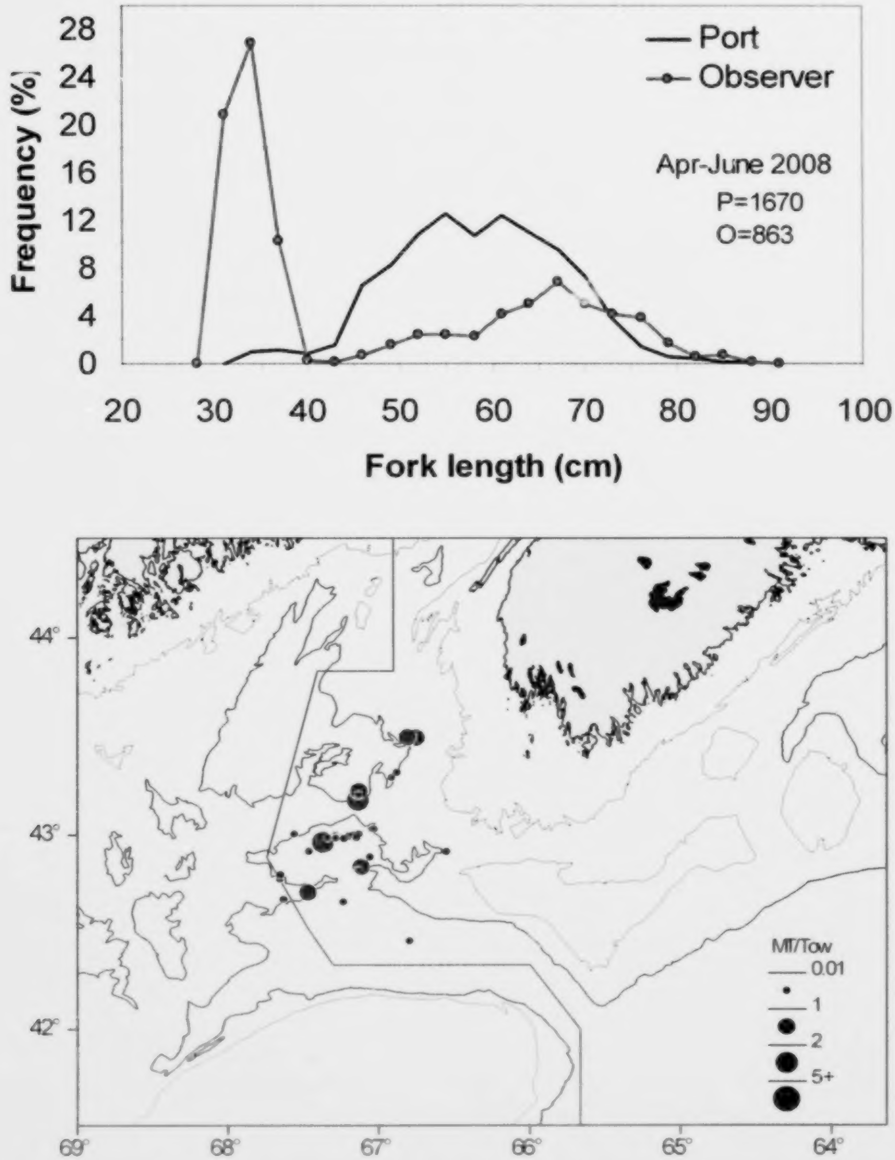


Fig. 9. Comparisons of 2008 port (dockside) and observer (at-sea) sample length measurements of pollock bycatch from the 4Xpq redfish fishery (upper panel) and location of observed sets (lower panel). Number of fish measured is shown for port (P) and observer (O) samples.

Between Ager Comparison

DFO	Consensus Ages (NMFS/DFO)									
Primary Ager	0	1	2	3	4	5	6	7	8	Total
0	2									2
1		6	1							7
2			9							9
3				10						10
4					9					9
5						8	3			11
6						1	8			9
7								7		7
8									2	2
Total	2	6	10	10	9	9	11	7	2	66

Agreement = 92%

Within Ager Comparison

	DFO Primary Ager (1st Reading)									
2nd reading	2	3	4	5	6	7	8	9	10	Total
2	4									4
3		30	1							31
4			16	2						18
5			1	18	1					20
6					14	2				16
7					1	8	1			10
8							7			7
9							1	3		4
10								1	2	3
11									1	1
Total	4	30	18	20	16	10	9	4	3	114

Agreement = 89%

Fig. 10. Age frequency plots comparing pollock age interpretations by the primary ager for the 4VWX+5 pollock stock. Top panel: Comparison of primary ager with NMFS/DFO ages from the 2001 Canada/US Ageing Workshop. Lower panel: Results of primary ager self-testing using pollock otolith sections from the 2007 fishery in 4X.

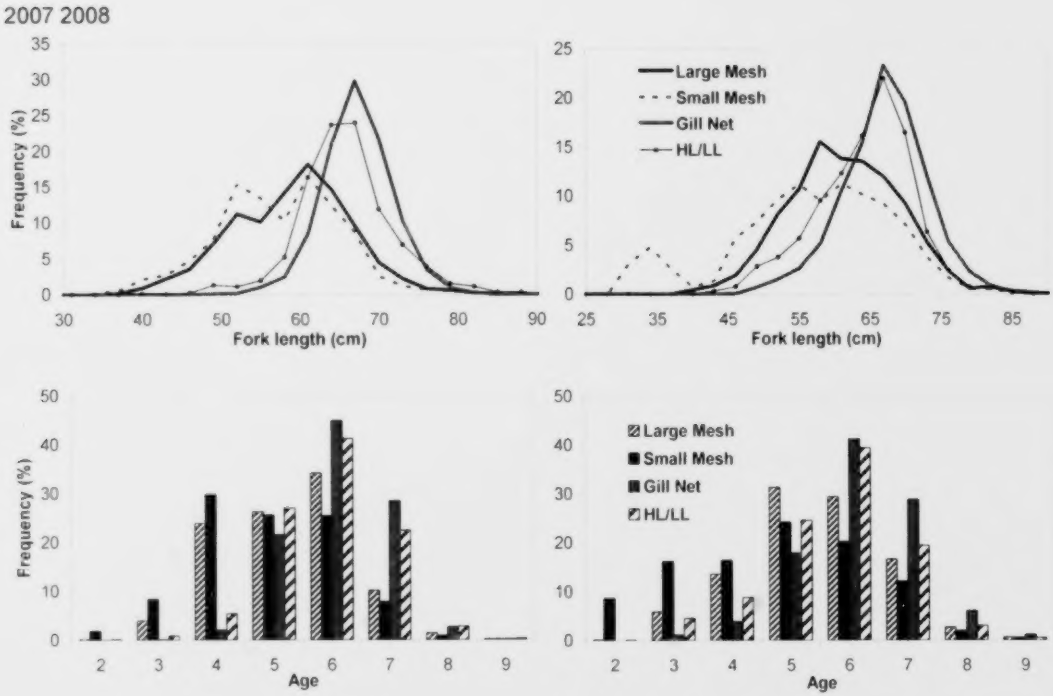


Fig. 11. Percentage catch at size (upper panel) and age (lower panel) of pollock from large mesh otter trawl (cod end mesh ≥ 130 mm), small mesh otter trawl (cod end mesh < 130 mm), gillnet and handline/ longline from the 2007 and 2008 fisheries in the Western Component area (data for 2008 is from Jan.-Aug.).

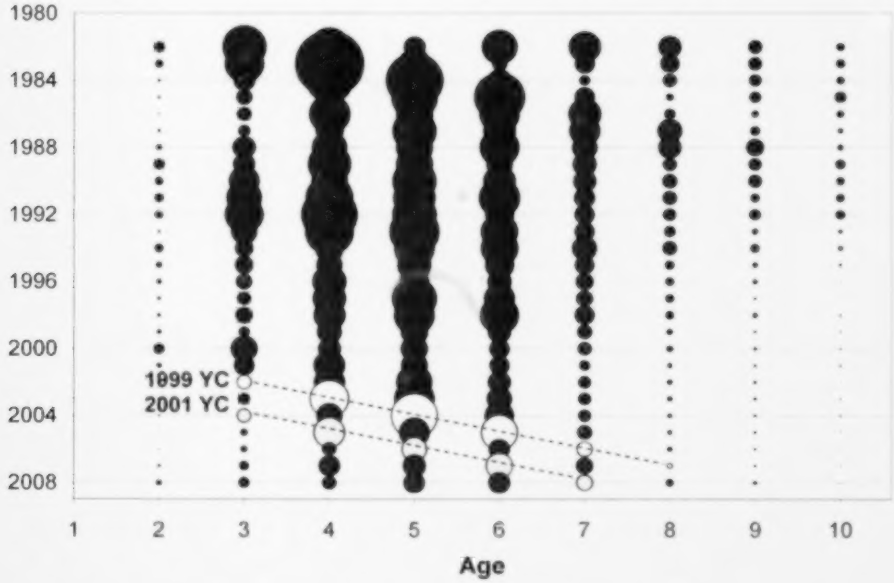


Fig. 12. Catch at age for pollock from the Western Component, 1982-2008. The area of the circle is proportional to the catch at that age and year. Two examples of recent strong cohorts are highlighted (data for 2008 is from Jan.-Aug.).

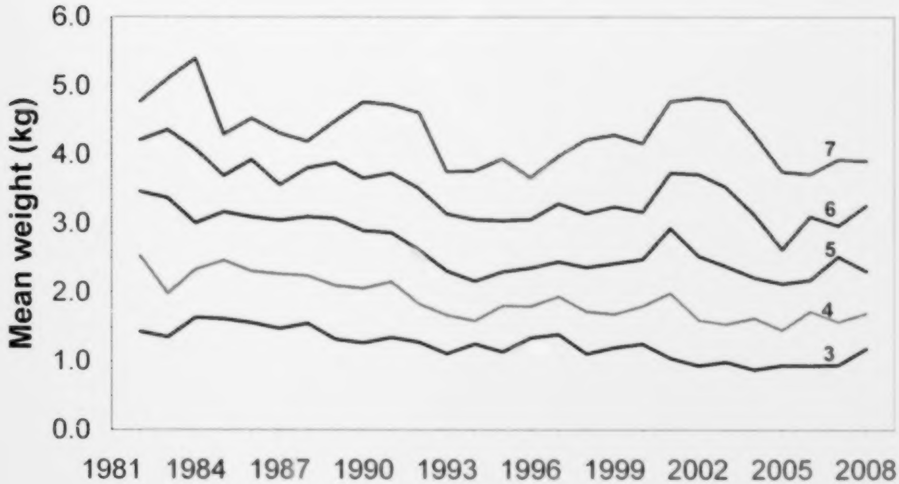


Fig. 13. Trends in fishery weights at age (kg) for pollock aged 3-7 from the Western Component, 1982-2008 (data for 2008 is from Jan.-Aug.).

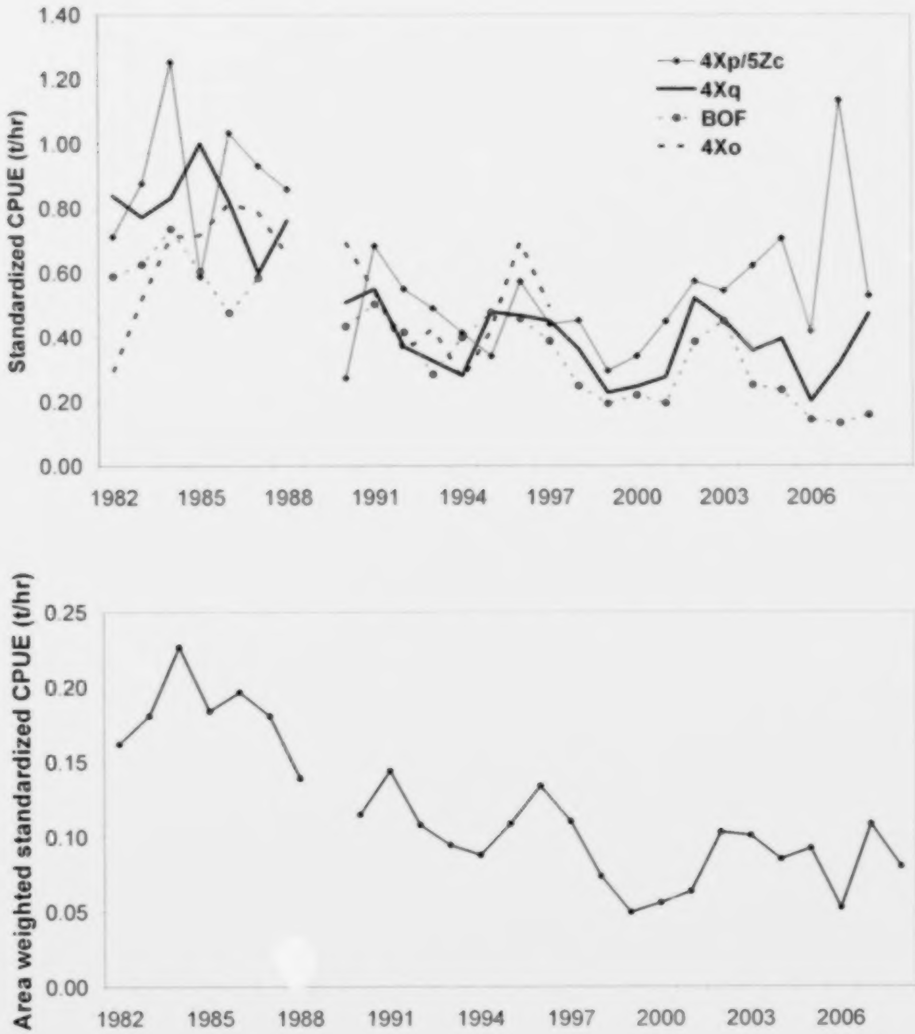


Fig. 14. Standardized mobile gear (OTB 1-3) catch rate series (t/hr) for pollock for the Western Component, 1982-2008. Upper panel: CPUE by area; lower panel: area weighted CPUE for combined areas (data for 2008 is from Jan.-Aug.).

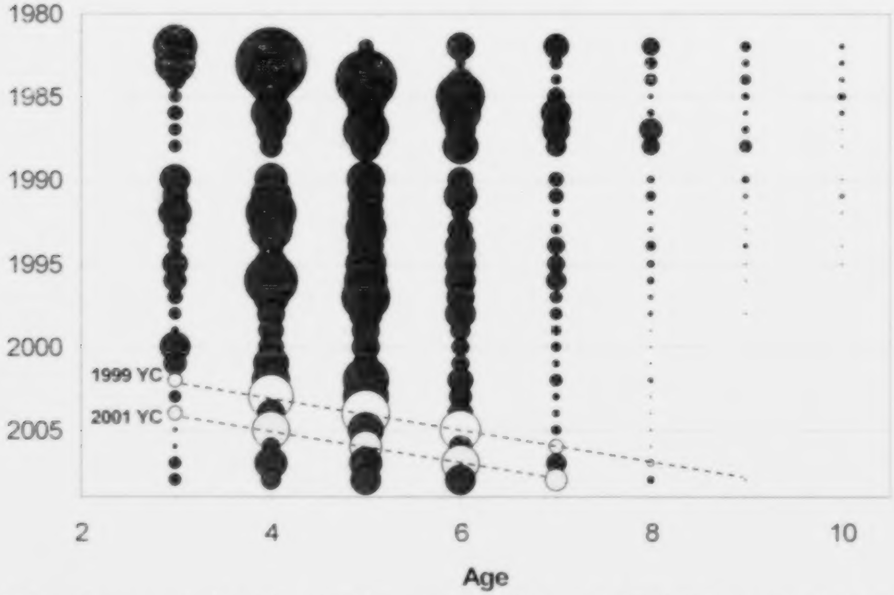


Fig. 15. Age-disaggregated catch rates for small mobile gear (TC 1-3) operating in the Western Component, 1982-2008. Two examples of recent strong cohorts are highlighted (data for 2008 is from Jan.-Aug.).

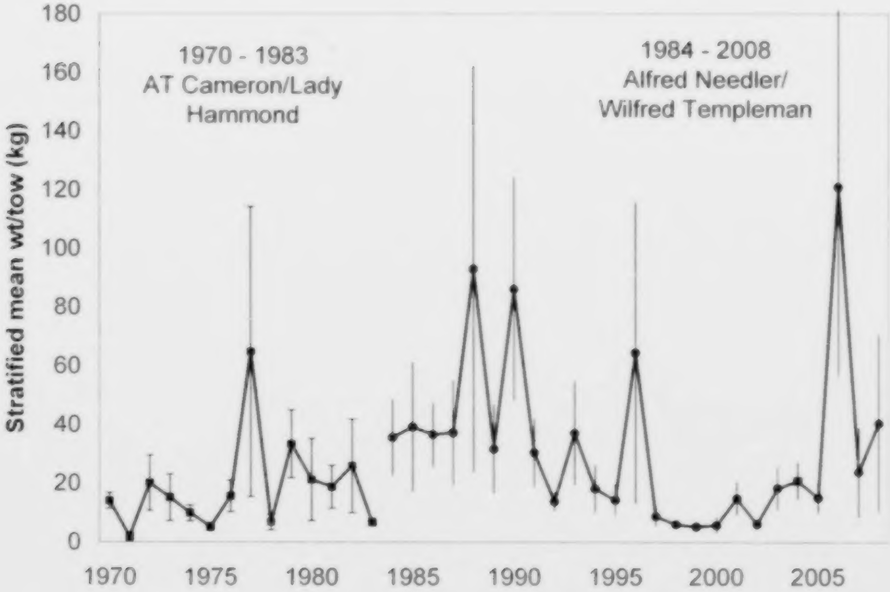


Fig. 16. Stratified mean catch per tow (kg) of pollock from the DFO summer RV survey in 4X strata (stratas 474, 476, and 480-495) corresponding to the Western Component, 1970-2008. Data from 1984 to present is used in the VPA.

2007

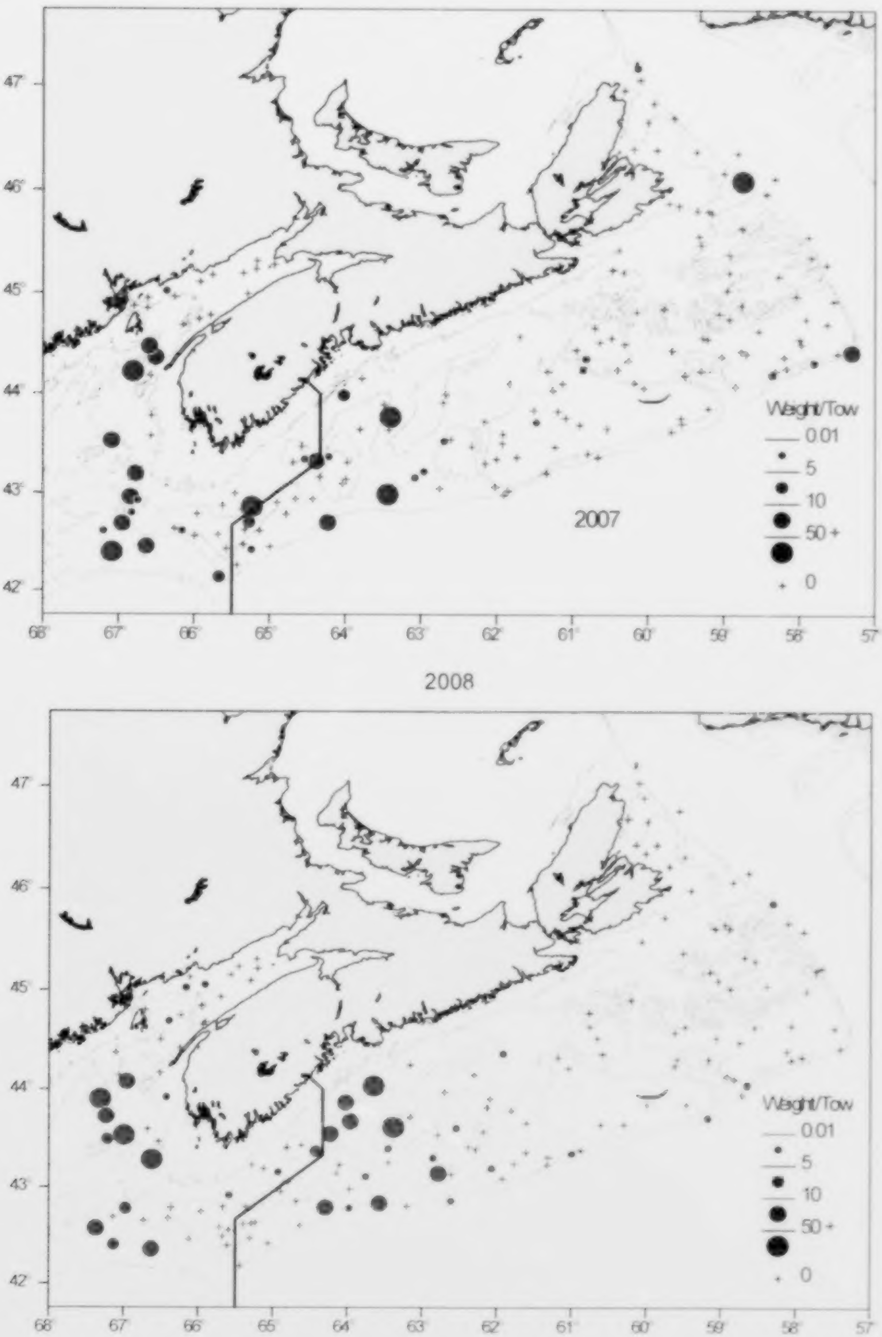


Fig. 17. Pollock biomass distribution (kg/tow) from the 2007 and 2008 DFO summer survey. The solid line separates the Eastern and Western components.

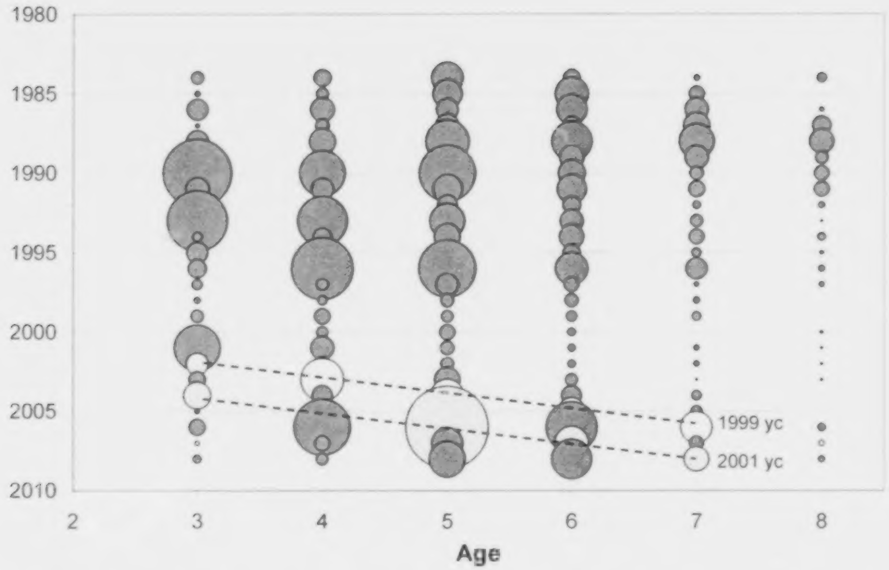


Fig. 18. Stratified mean number per tow at age of pollock from the DFO summer RV survey in 4X strata corresponding to the Western Component, 1984-2008.

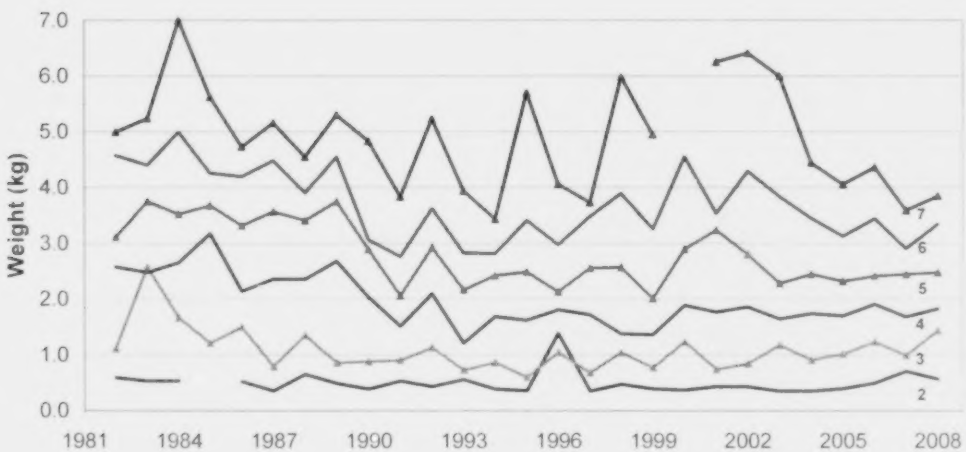
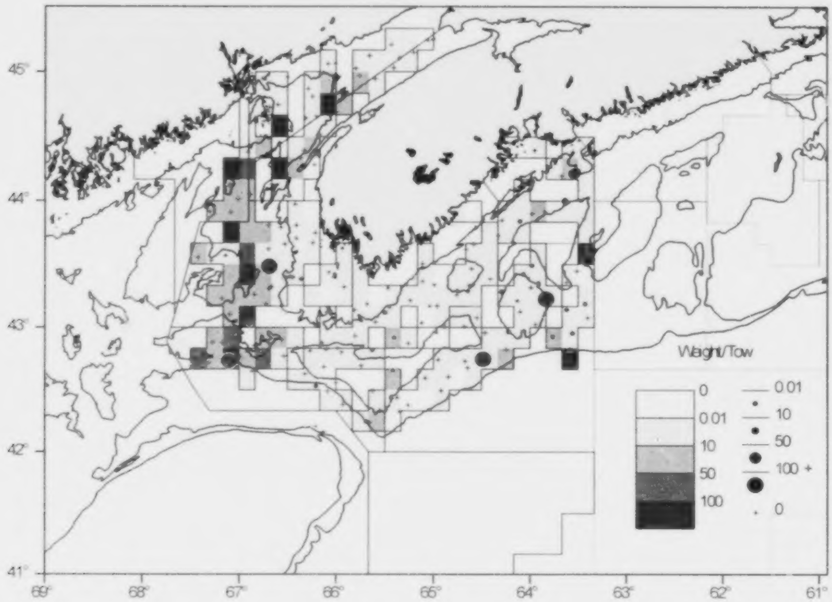


Fig. 19. Weight at age for pollock ages 2-7 from the DFO summer RV survey in 4X strata corresponding to the Western Component, 1982-2008.

2007



2008

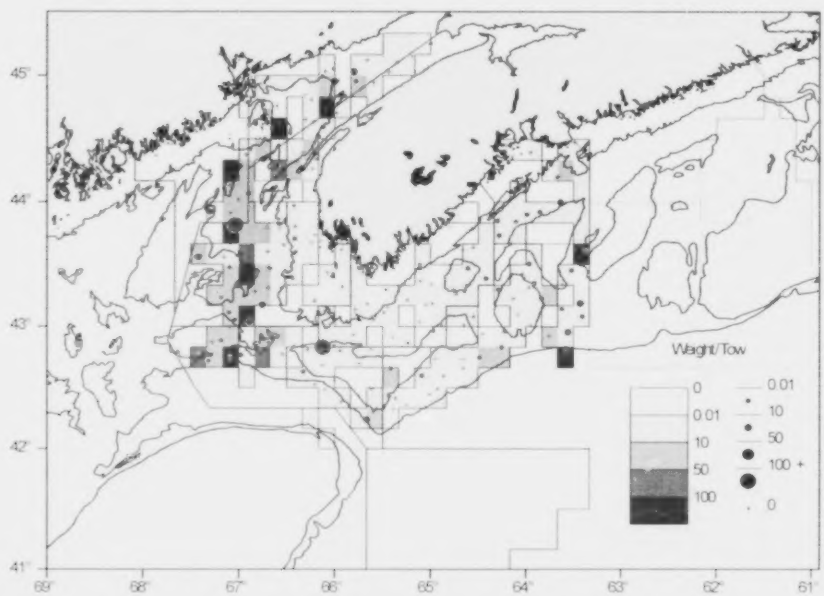


Fig. 20. ITQ survey pollock biomass (kg/tow) distribution for 2007 and 2008 (solid circles), shown with respect to the average catch over the past 10 years (shaded rectangles).

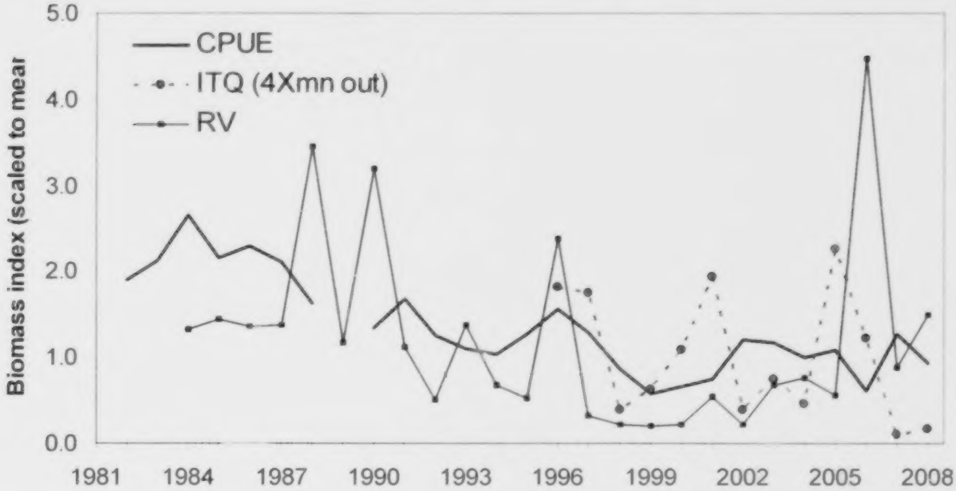


Fig. 21. Trends in pollock biomass indices from the mobile gear CPUE series (1982-2008), DFO RV survey (1984-2008) and the ITQ survey (1996-2008) for the Western Component area.

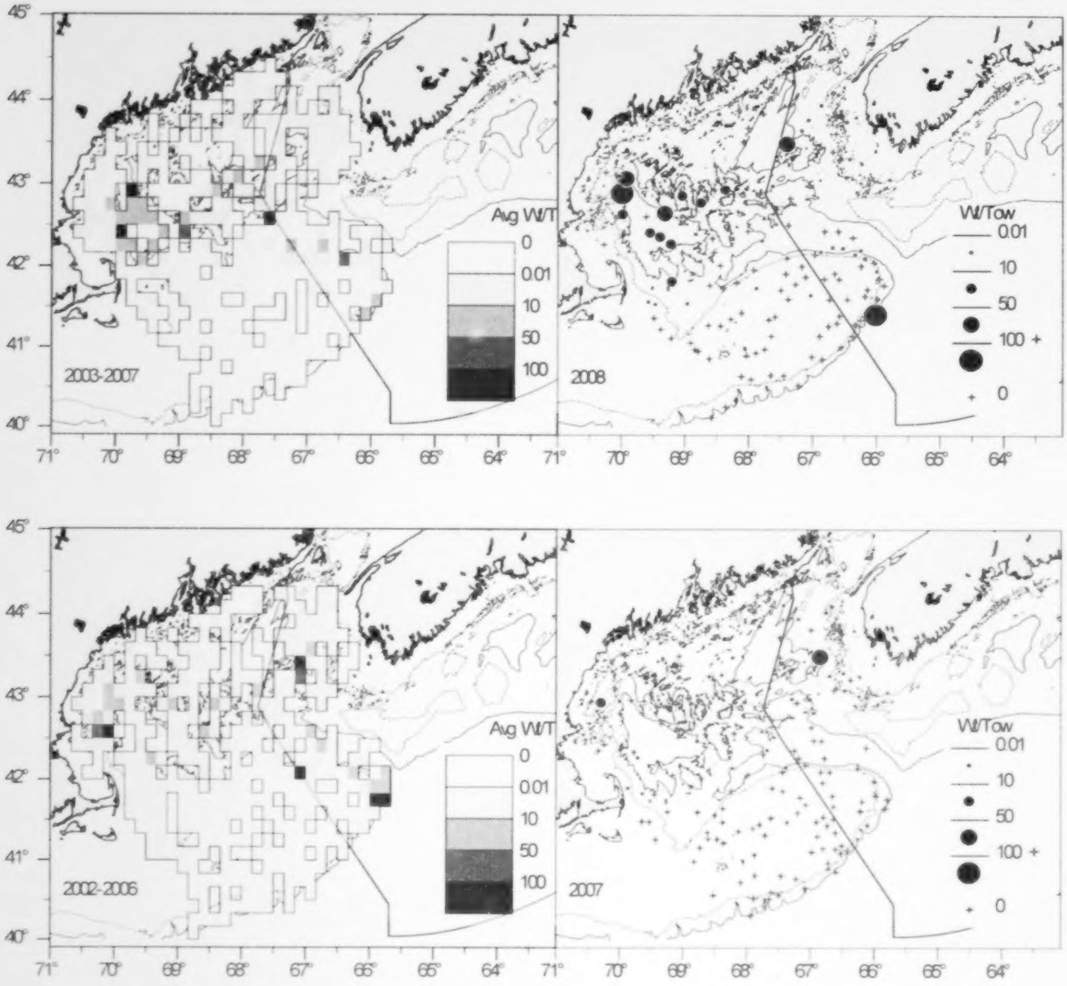


Fig. 22. NMFS bottom trawl survey biomass distribution (kg/tow) for spring (upper panel) and fall (lower panel) surveys conducted in 2008 and 2007, respectively (solid circles) compared with the average for the previous 5 years (shaded rectangles). The solid line indicates the International Boundary.

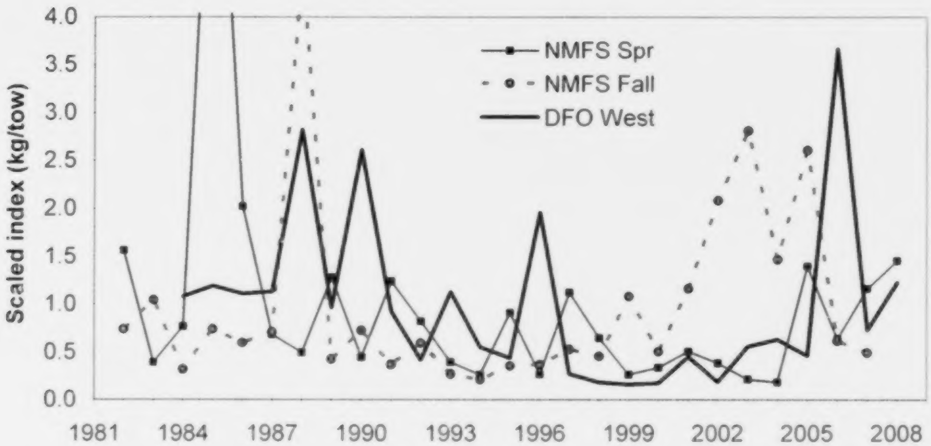


Fig. 23. Comparison of biomass indices (kg/tow, scaled to mean of series) from the NMFS spring, NMFS fall and DFO RV surveys.

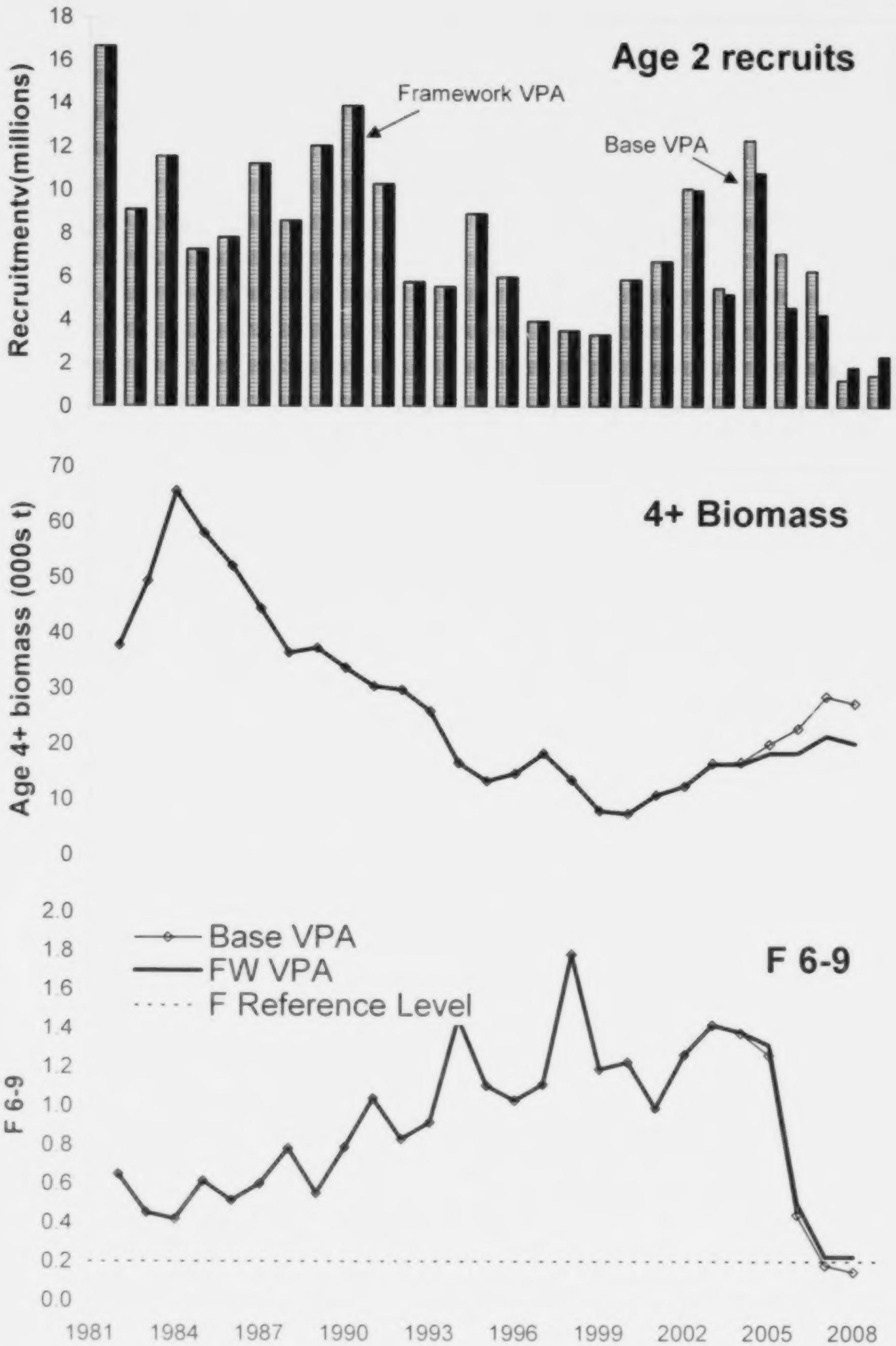


Fig. 24. Comparison of trends in age 2 recruitment, 4+ biomass, and age 6-9 fishing mortality for the Western Component from the Base VPA (CPUE: 1982-2004) and the Framework VPA (CPUE: 1982-2008).

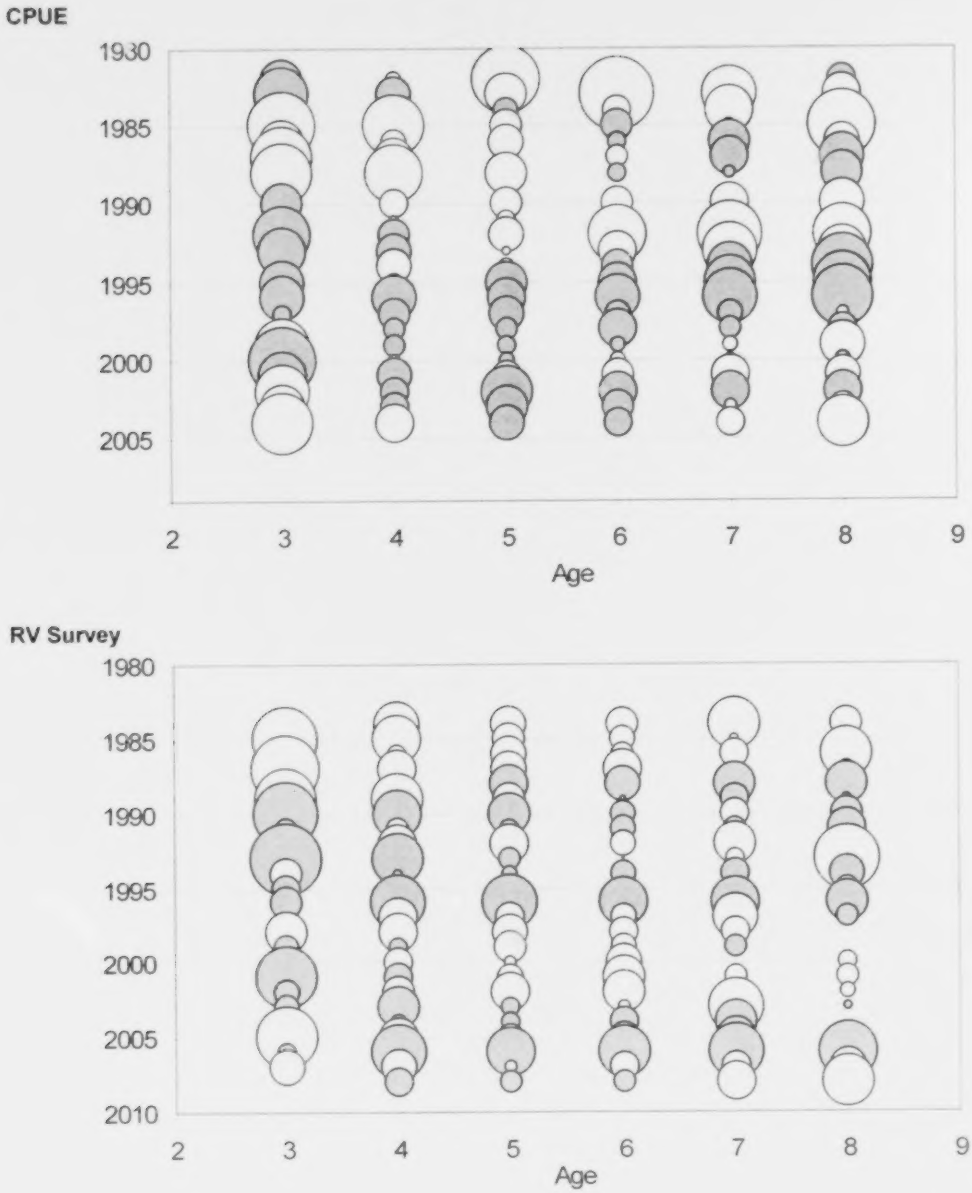


Fig. 25. Age-specific residuals for the Base VPA formulation, Western Component pollock, for the relationships between *ln* abundance index versus *ln* population numbers for the CPUE series (upper panel) and the RV series (lower panel). Closed circles denote positive residuals and open circles denote negative residuals. (Bubble size is proportional to magnitude).

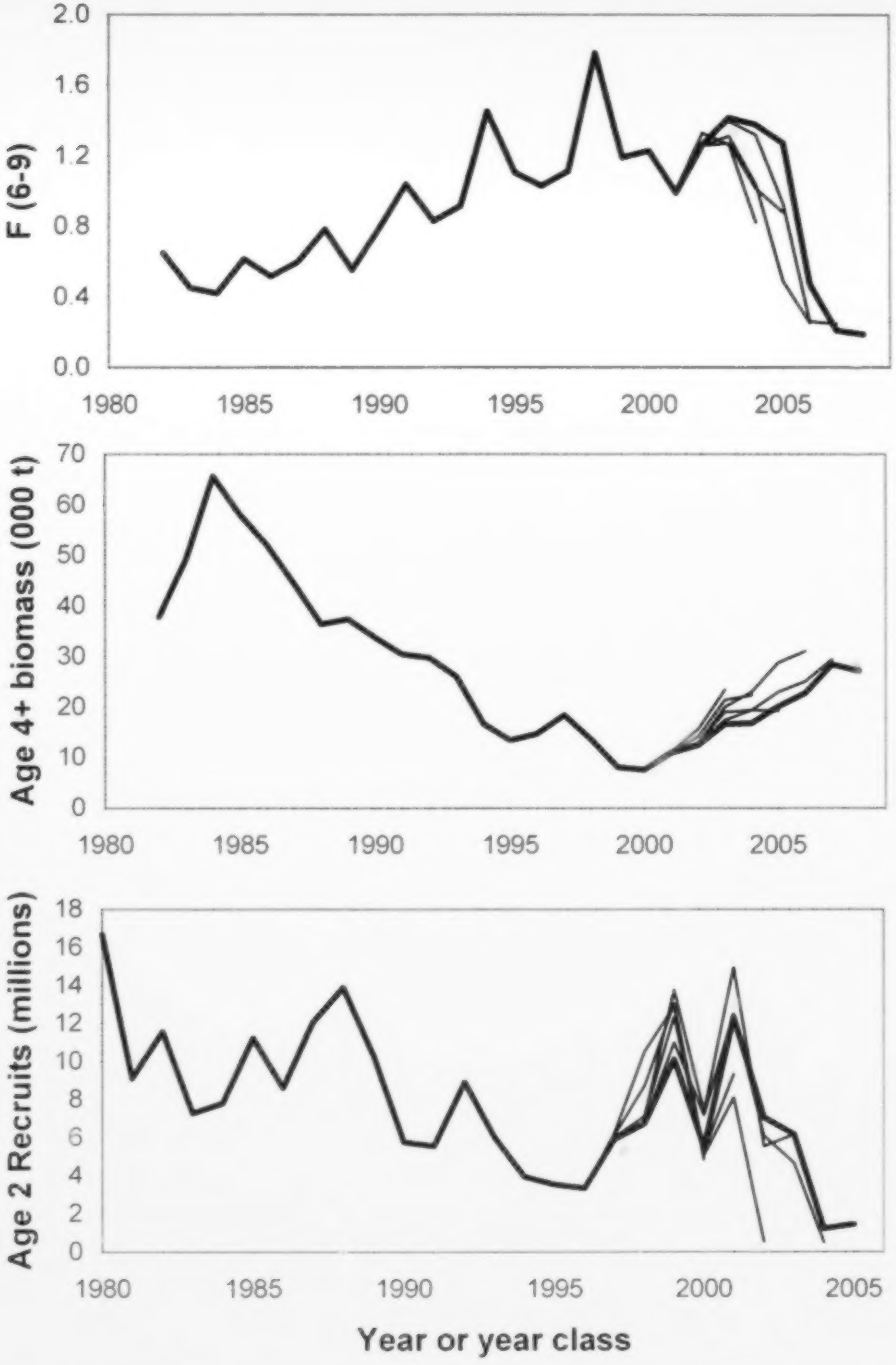


Fig. 26. Retrospective analysis of Western Component pollock from the Base VPA for age 6-9 fishing mortality (top panel), age 4+ biomass (middle panel), and age 2 recruits (lower panel).

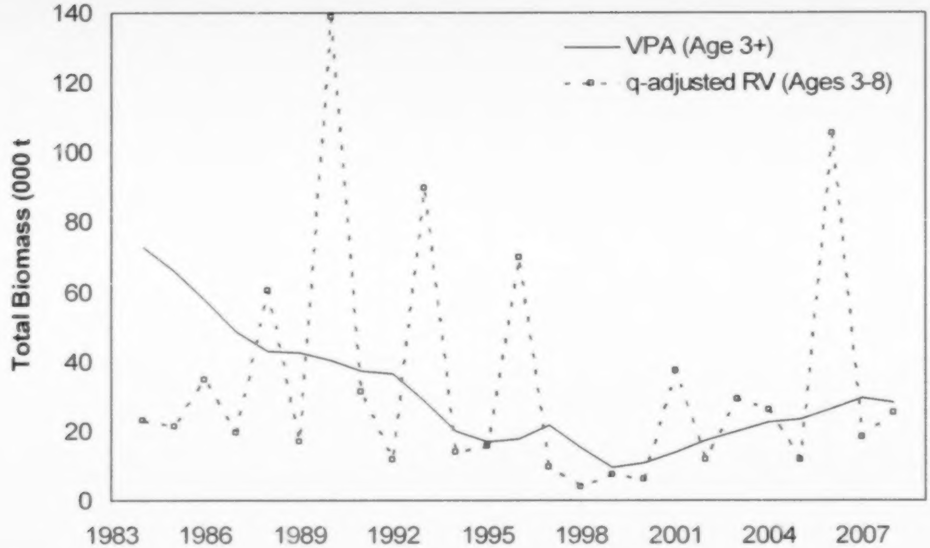


Fig. 27. Base VPA 3+ population biomass compared to the *q*-adjusted survey total biomass for ages 3-8 for the Western Component.

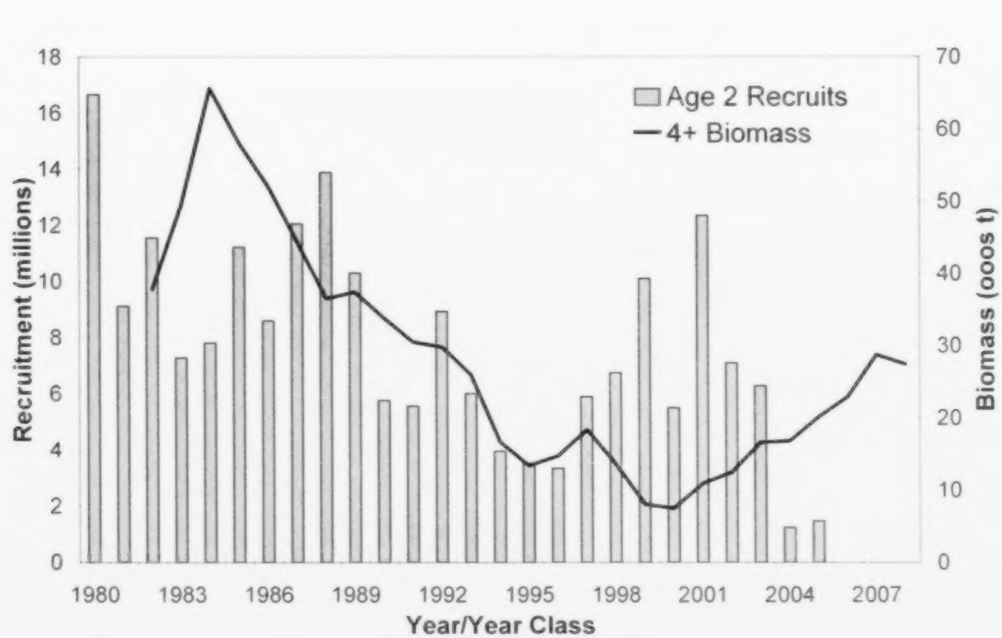


Fig. 28. Trends in age 4+ biomass and age 2 recruitment of pollock in the Western Component from the Base VPA formulation.

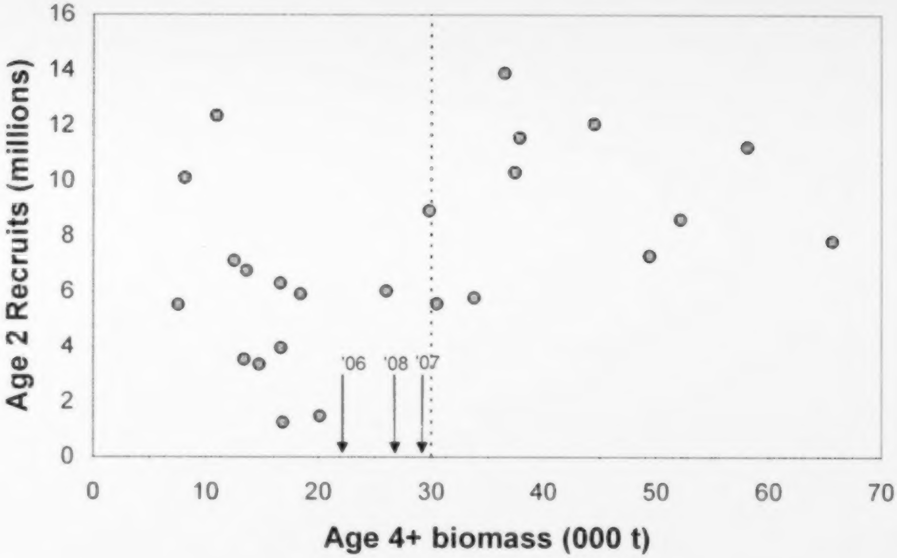


Fig. 29 Age 4+ biomass and age 2 recruitment relationship from the Base VPA model for the Western Component. The beginning of year age 4+ biomass is shown for 2006-2008.

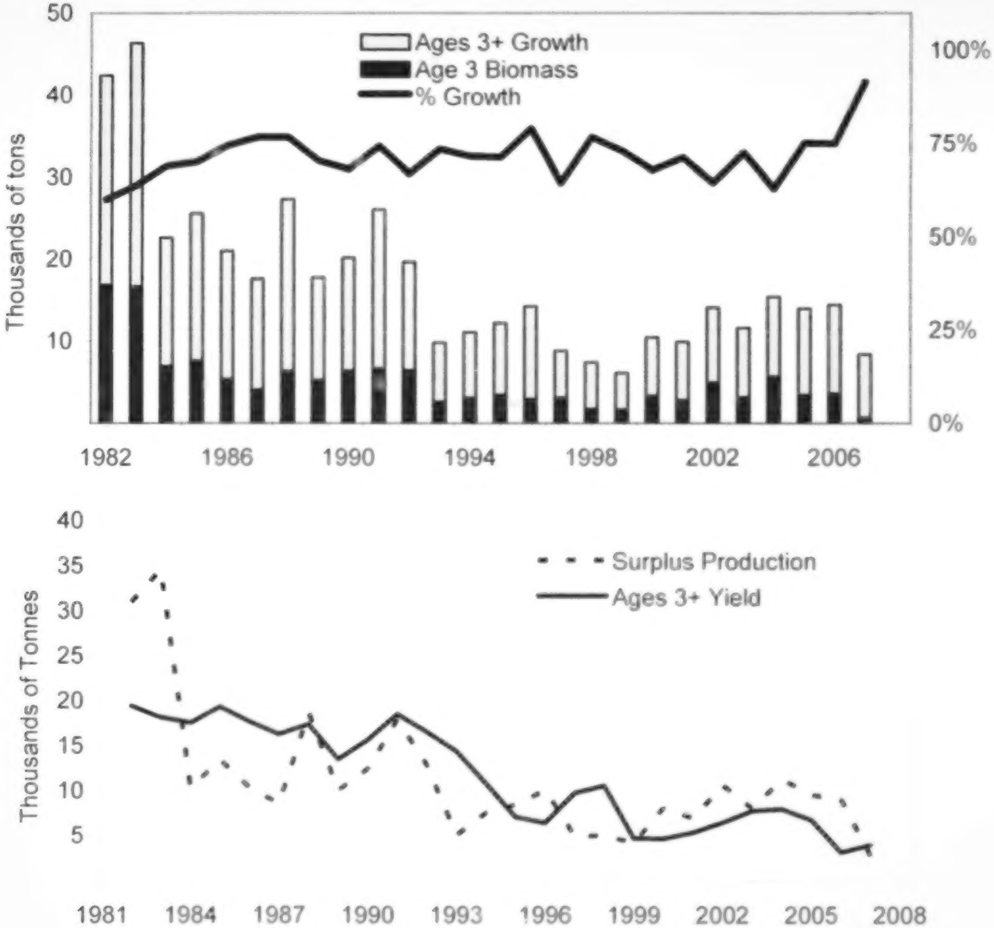


Fig. 30 Components of production (top panel) and production as indicated by the Base VPA compared with fishery yield (bottom panel) for the Western Stock Component.

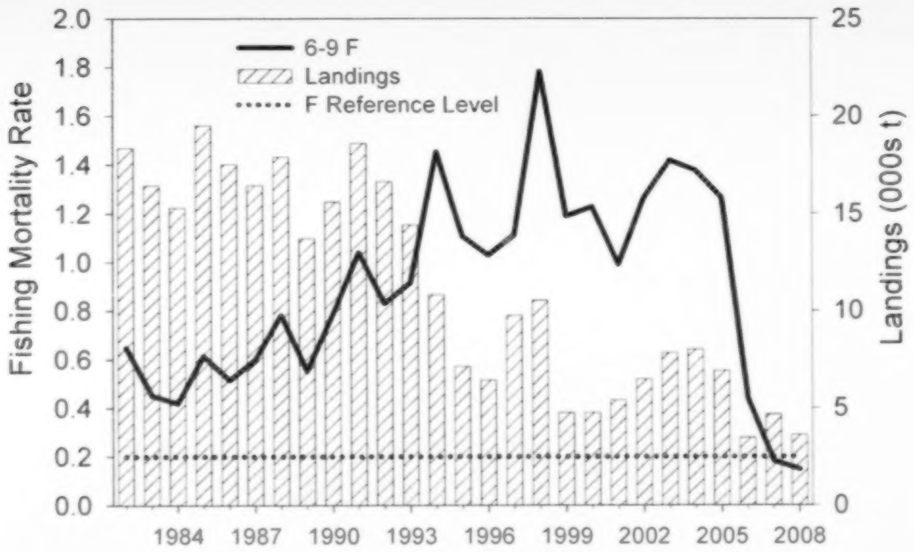


Fig. 31. Trends in fishing mortality and landings of pollock for the Western Component from the Base VPA formulation.

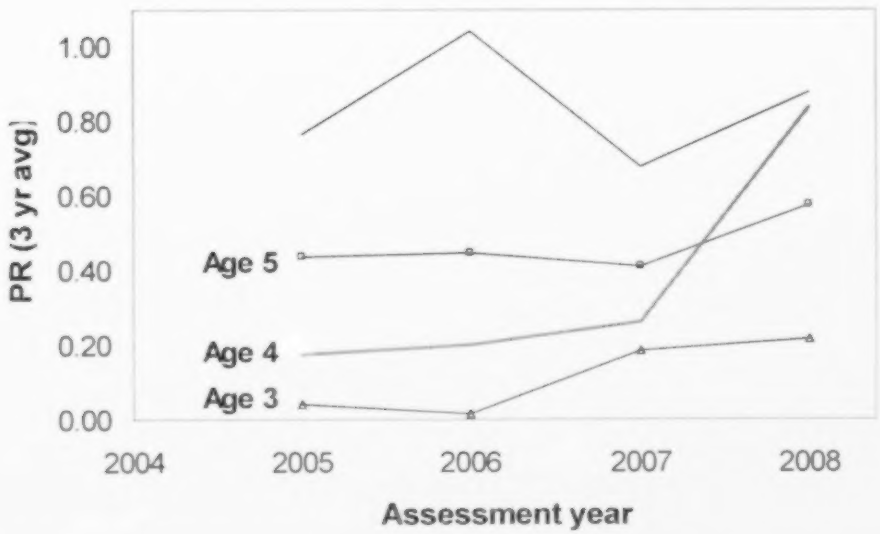


Fig. 32. Partial recruitment values (3-year average) Western Component VPA results used in past assessments for projections and risk analyses.

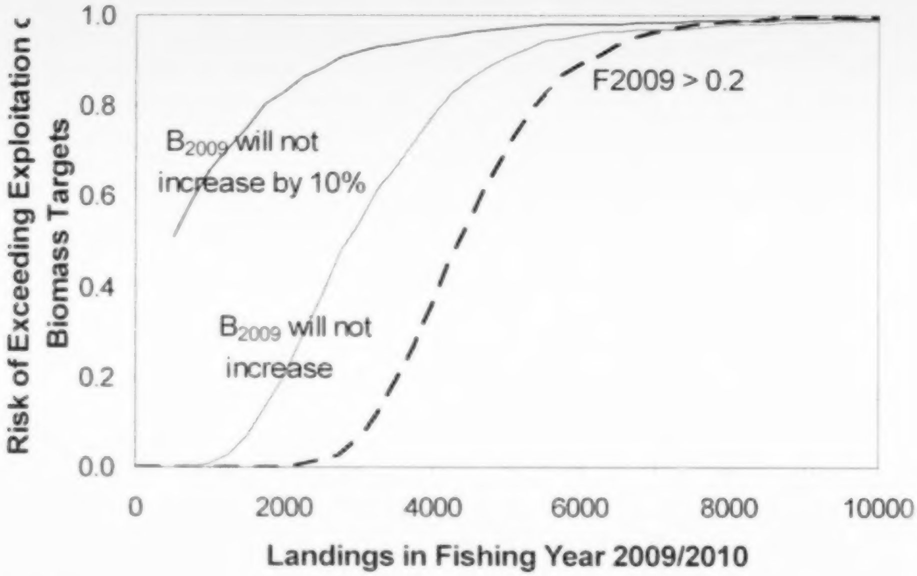


Fig. 33. Risk of exceeding age 5+ exploitation or biomass rebuilding targets for Western Component from the Base VPA formulation.

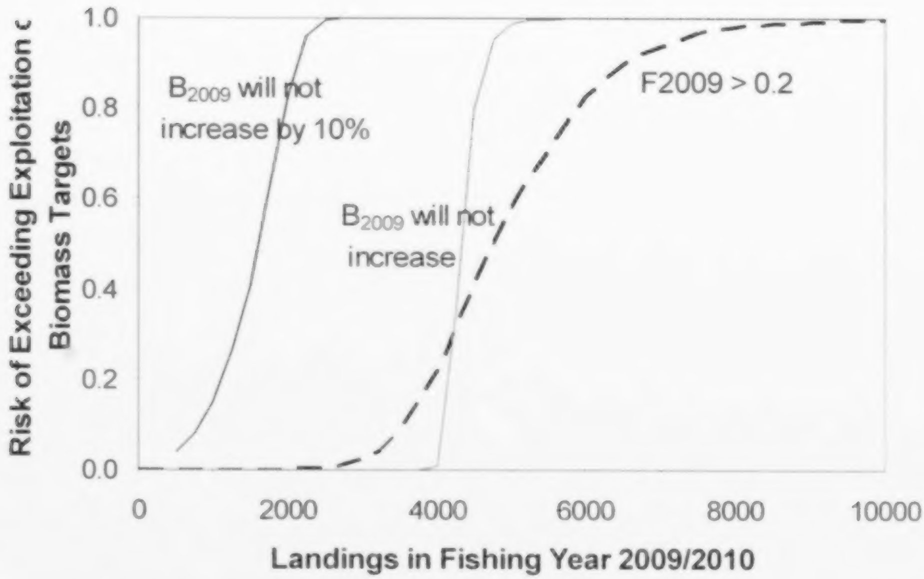


Fig. 34. Risk of exceeding age 5+ exploitation or biomass rebuilding targets for Western Component from the Base VPA formulation with assigned recruitment (3.4 million) at age 2 from 2006-2008.

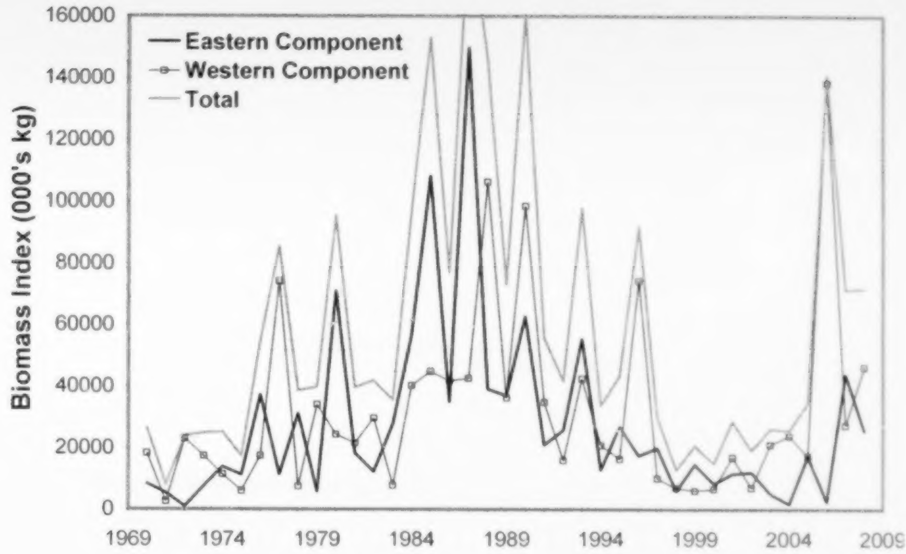


Fig. 35. RV survey biomass indices from the Eastern and Western components, 1970-2008.

Fig. 36. Stratified mean number per tow at age of pollock from the DFO summer RV survey in strata corresponding to the Eastern Component, 1984-2008. The 2007 and 2008 survey values are shaded white and brown, respectively.

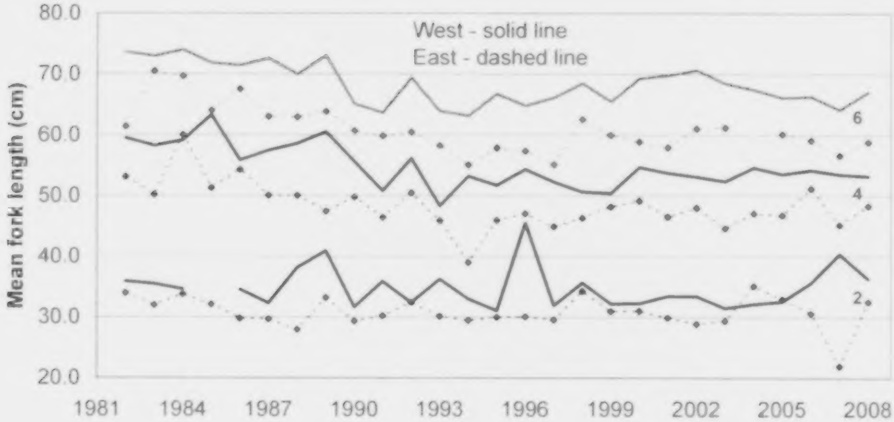


Fig. 37. Weight at age for pollock ages 2, 4, and 6, from the DFO summer research vessel survey in strata corresponding to the Western and Eastern components, 1982-2008.

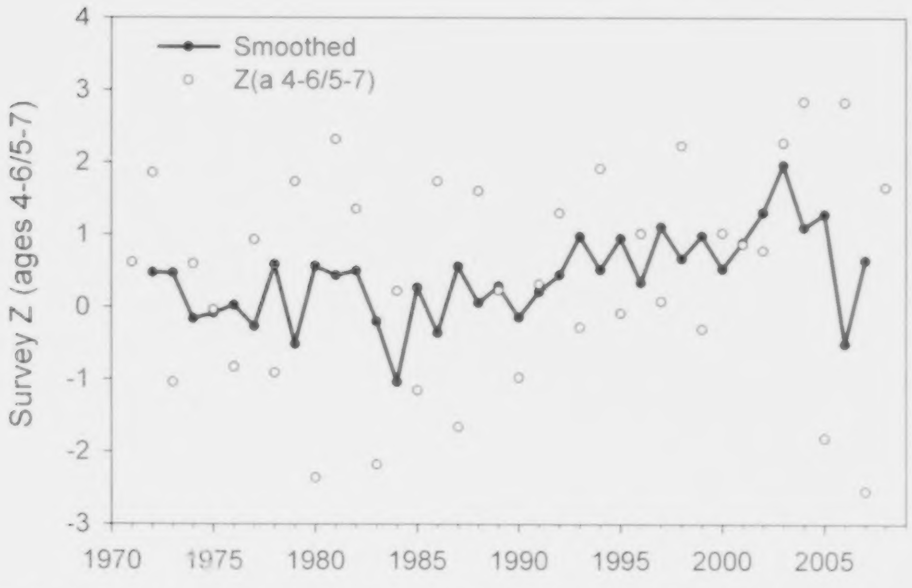


Fig. 38. Smoothed (running average of 3 year) estimates of total mortality from RV surveys, Eastern Component pollock. Annual estimates of total mortality (unsmoothed) are shown as open circles.

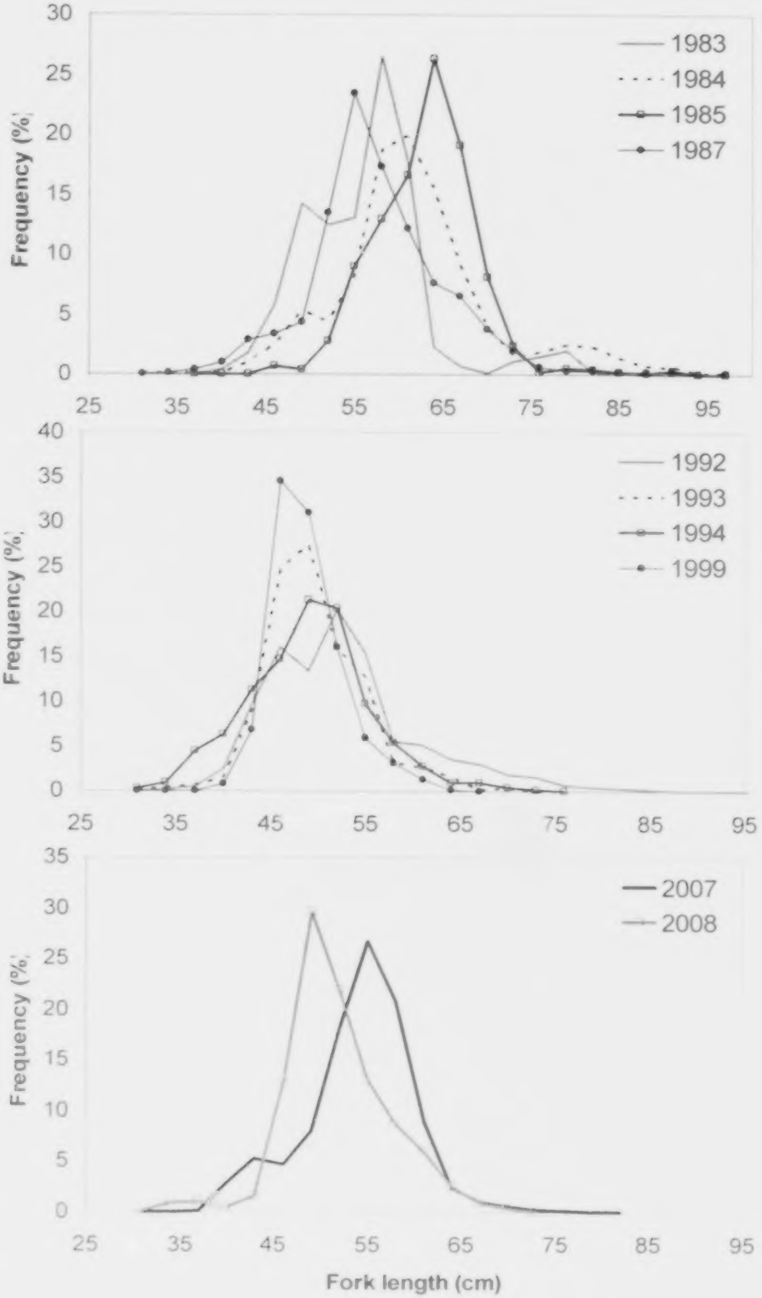


Fig. 39. Pollock catch at size frequencies from directed fisheries in the Eastern Component (4W) in the 1980s and 1990s, compared to test fisheries in 2007/2008.

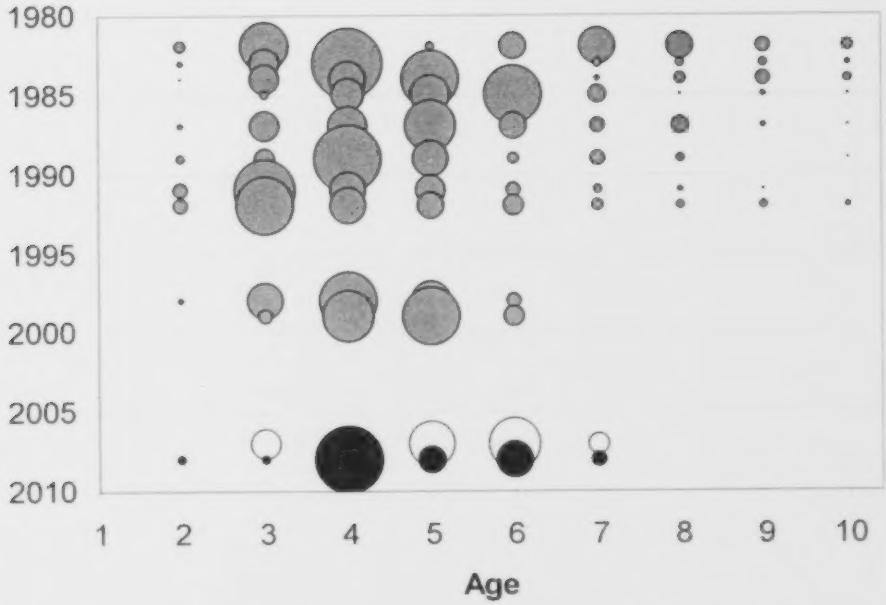


Fig. 40. Age composition of pollock catch by percentage from directed fisheries in the Eastern Component (4W) in the 1980s and 1990s, compared to test fisheries in 2007/2008. The 2007 and 2008 CAA values are shaded white and brown, respectively.

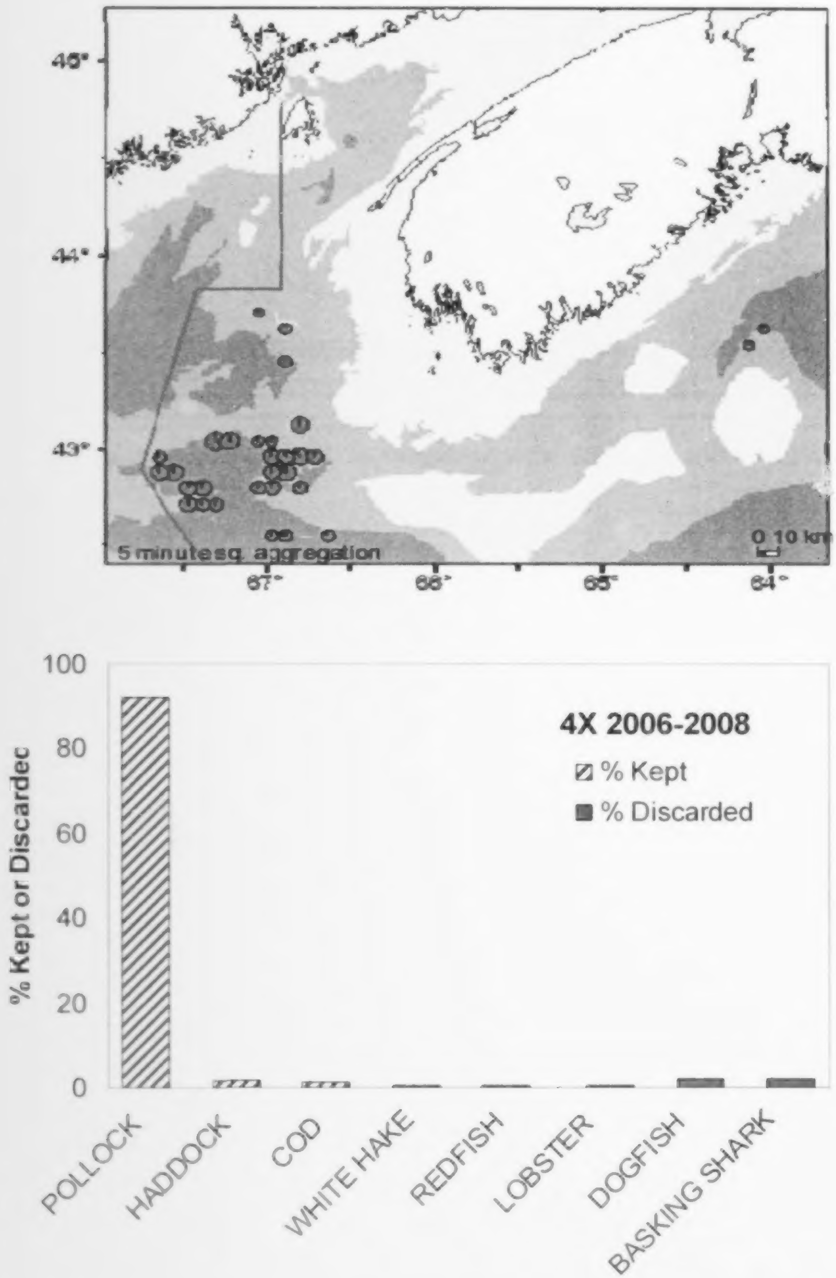


Fig. 41. Kept versus discarded bycatch reported for 2006-2008 combined observed trips in 4X from pollock-directed mobile gear trips. Top panel: observed set locations; bottom panel: percentage of catch kept and discarded by species.

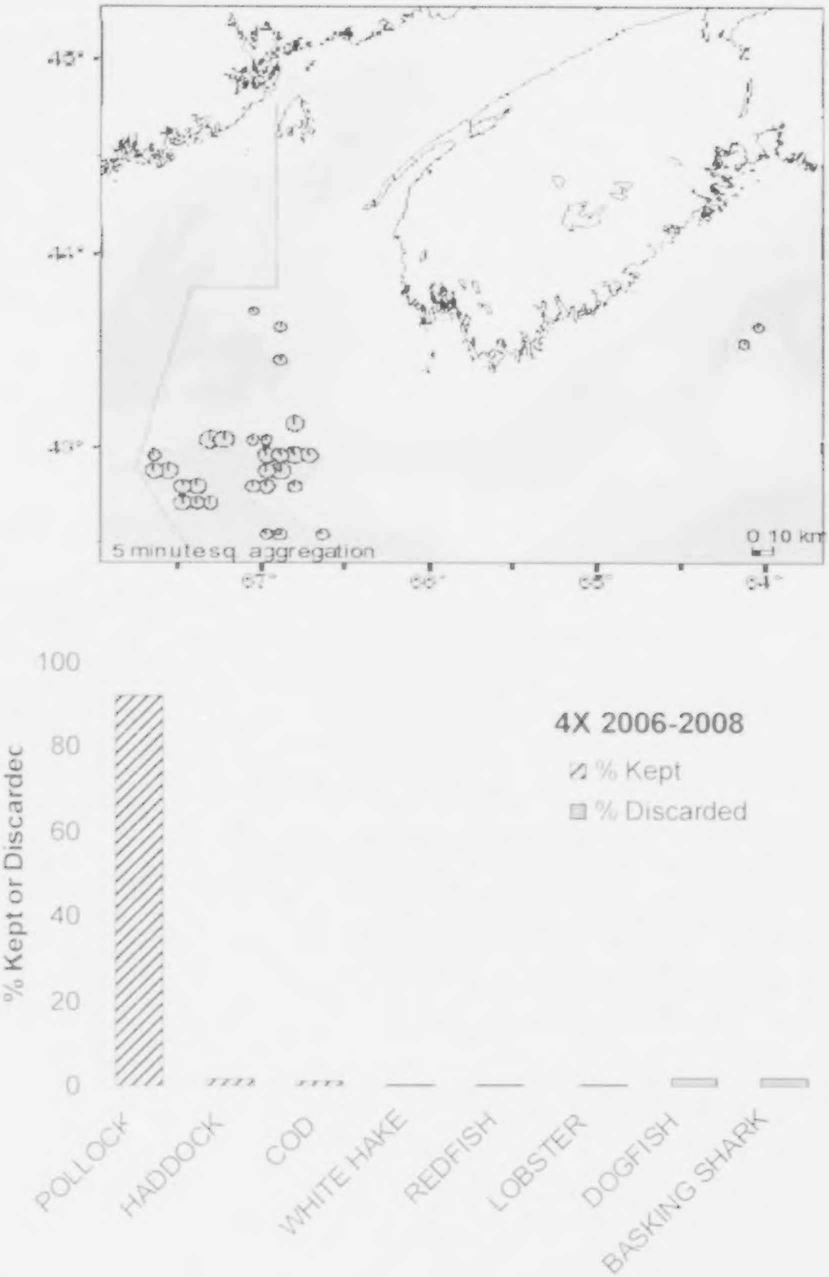


Fig. 41. Kept versus discarded bycatch reported for 2006-2008 combined observed trips in 4X from pollock-directed mobile gear trips. Top panel: observed set locations; bottom panel: percentage of catch kept and discarded by species.

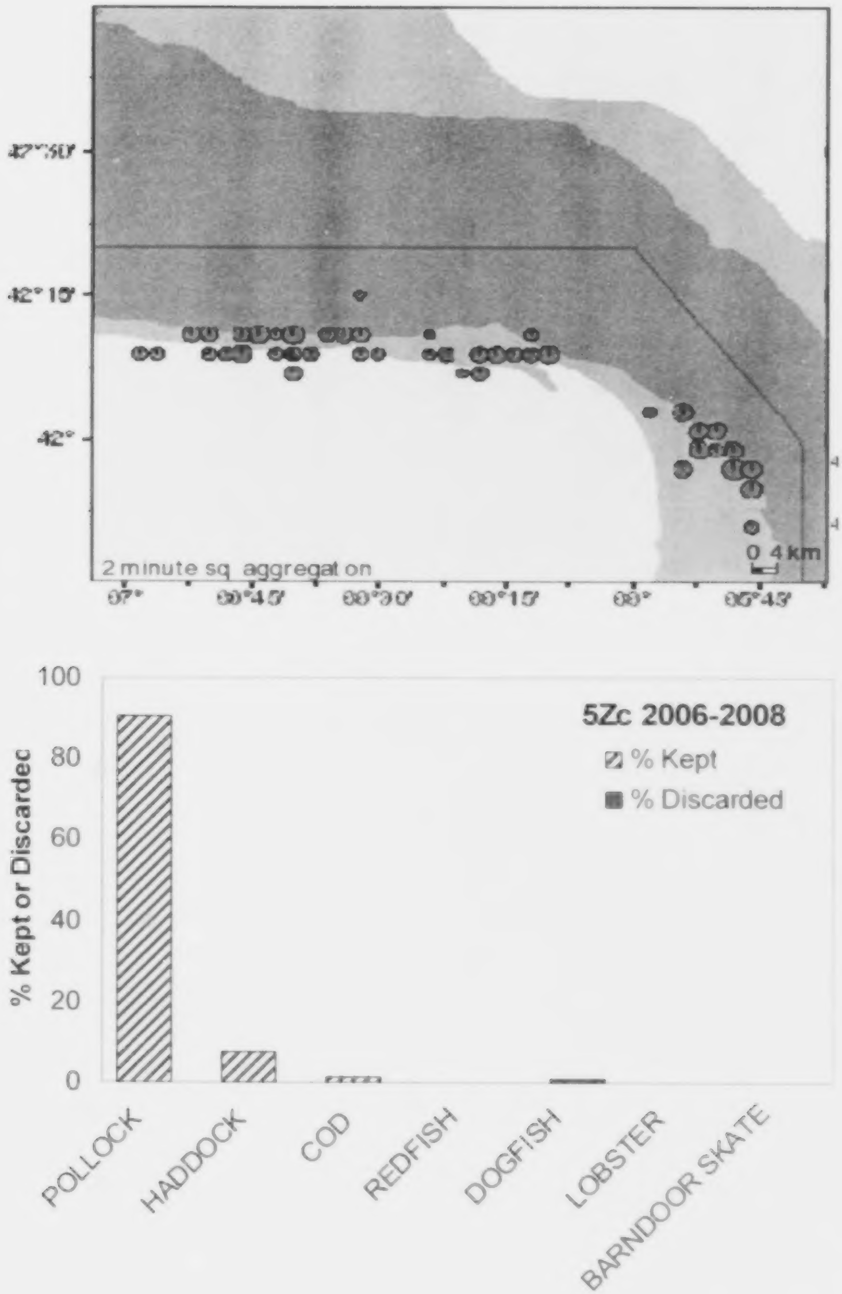


Fig. 42. Kept versus discarded bycatch reported for 2006-2008 combined observed trips in 5Zc from pollock-directed mobile gear trips. Top panel: observed set locations, northeast Georges Bank; bottom panel: percentage of catch kept and discarded by species.

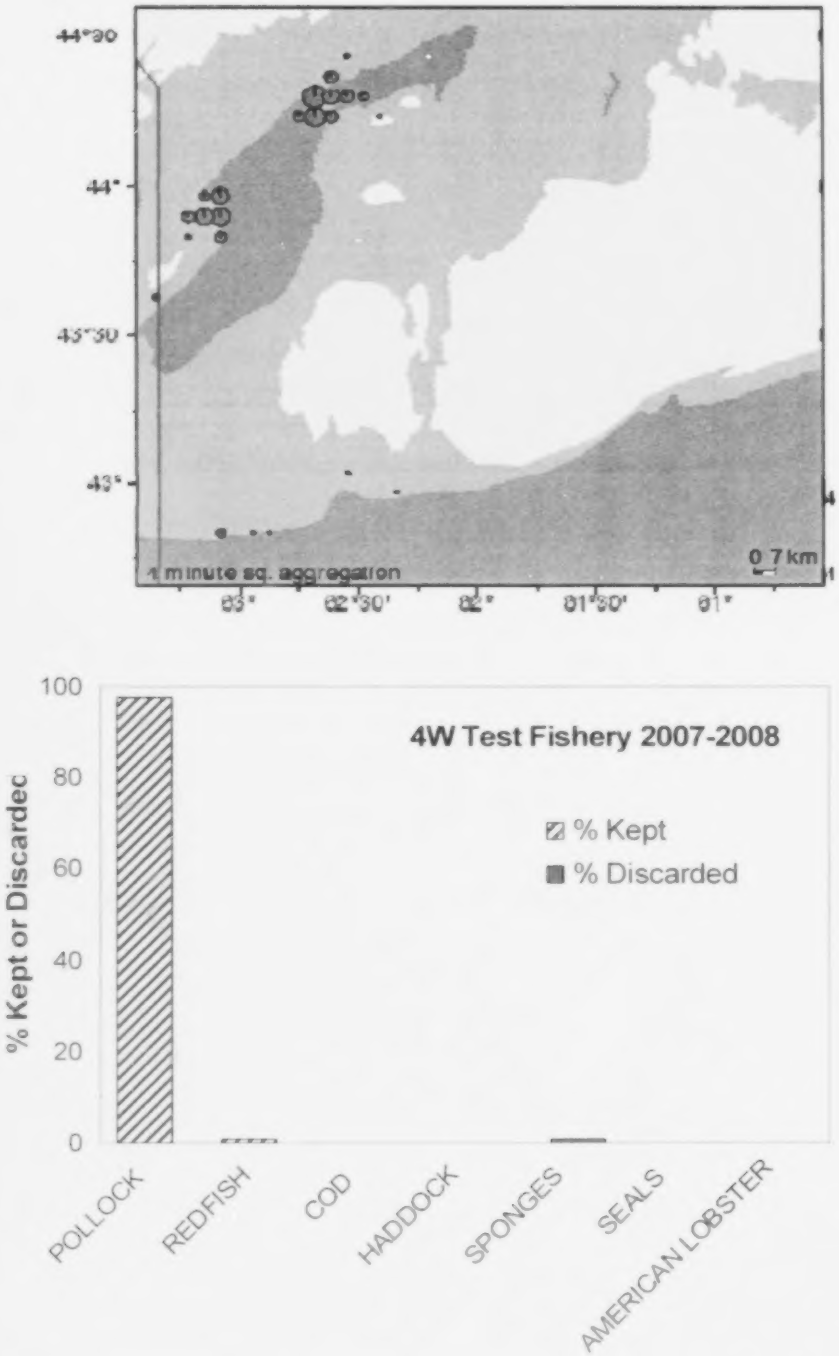


Fig. 43. Kept versus discarded bycatch reported for 2006-2008 combined observed trips in 4W from pollock-directed mobile gear trips. Top panel: observed set locations, 4Wkl; bottom panel: percentage of catch kept and discarded by species.

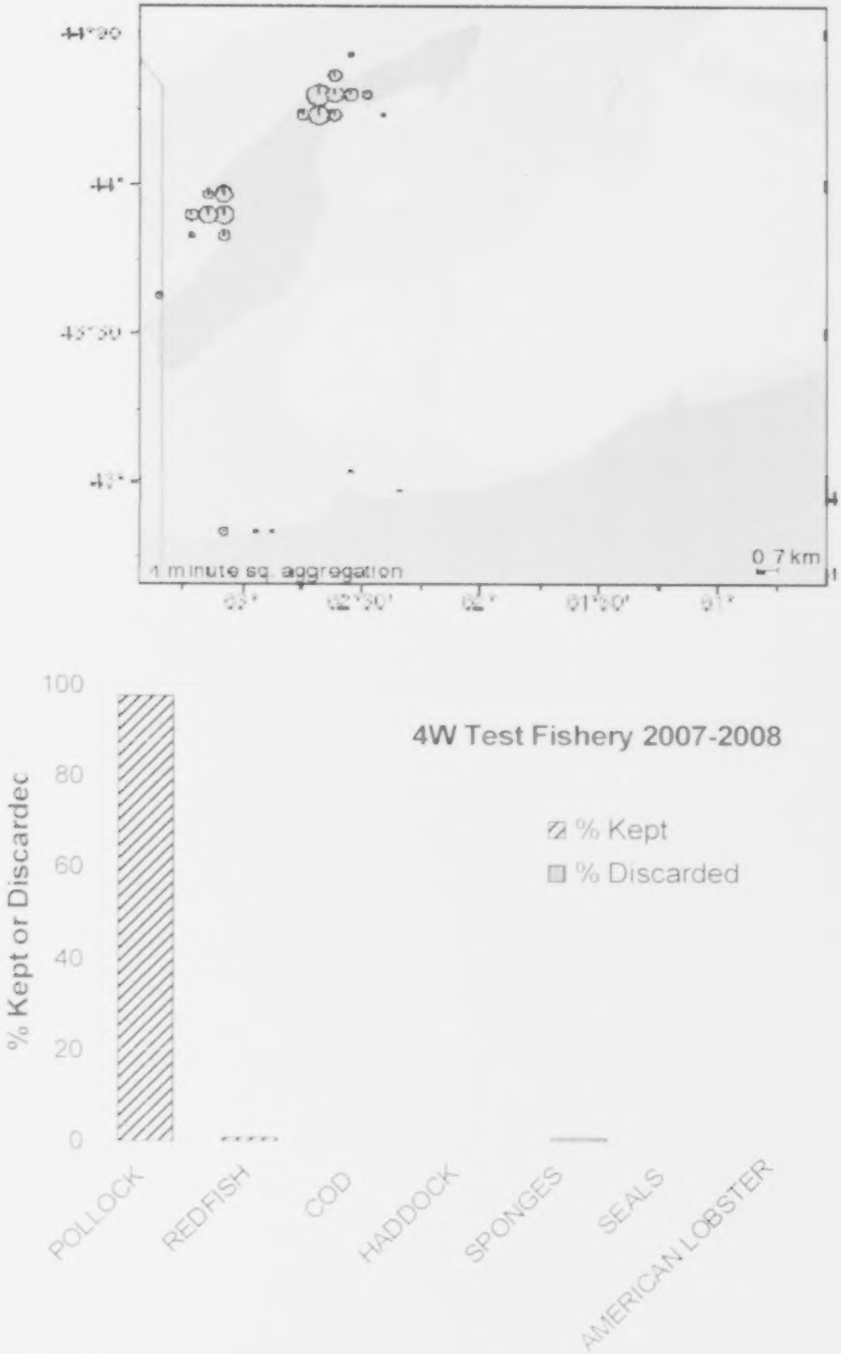


Fig. 43. Kept versus discarded bycatch reported for 2006-2008 combined observed trips in 4W from pollock-directed mobile gear trips. Top panel: observed set locations. 4Wkl; bottom panel: percentage of catch kept and discarded by species.

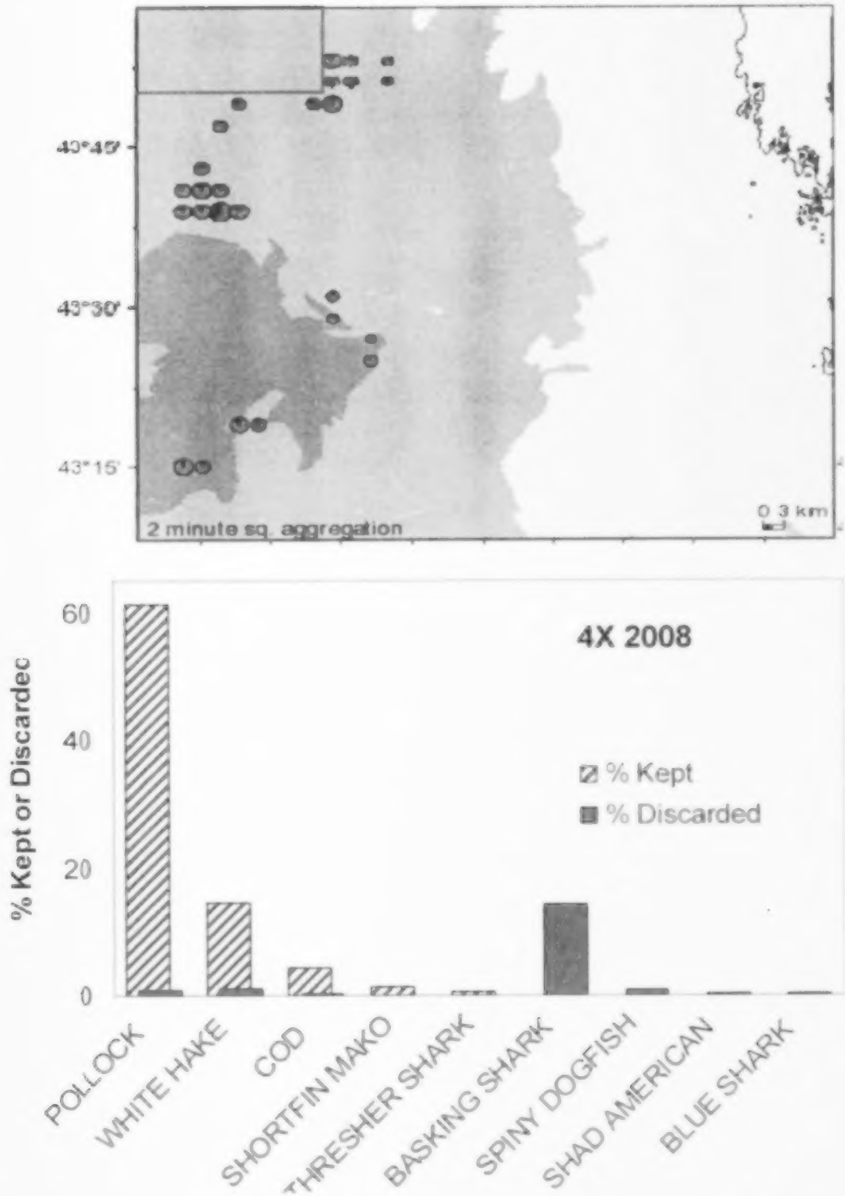


Fig. 44. Kept versus discarded bycatch reported for 2008 in 4X from pollock-directed observed gillnet trips. Top panel: observed set locations, 4Xq; bottom panel: percentage of catch kept and discarded by species.

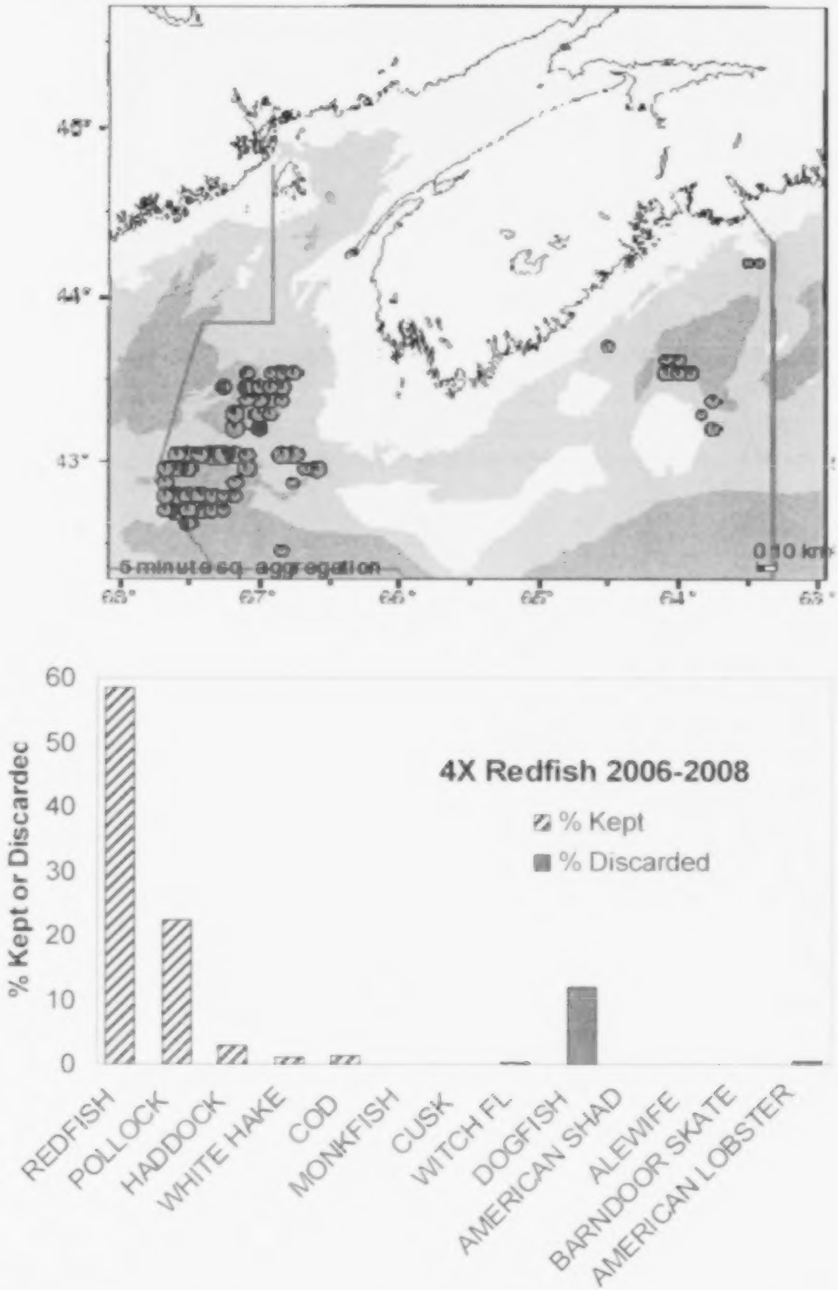


Fig. 45. Kept versus discarded bycatch reported for 2006-2006 combined observed trips in 4X from redfish-directed mobile gear trips. Top panel: observed set locations, 4Xpq and 4Xmn, bottom panel: percentage of catch kept and discarded by species.

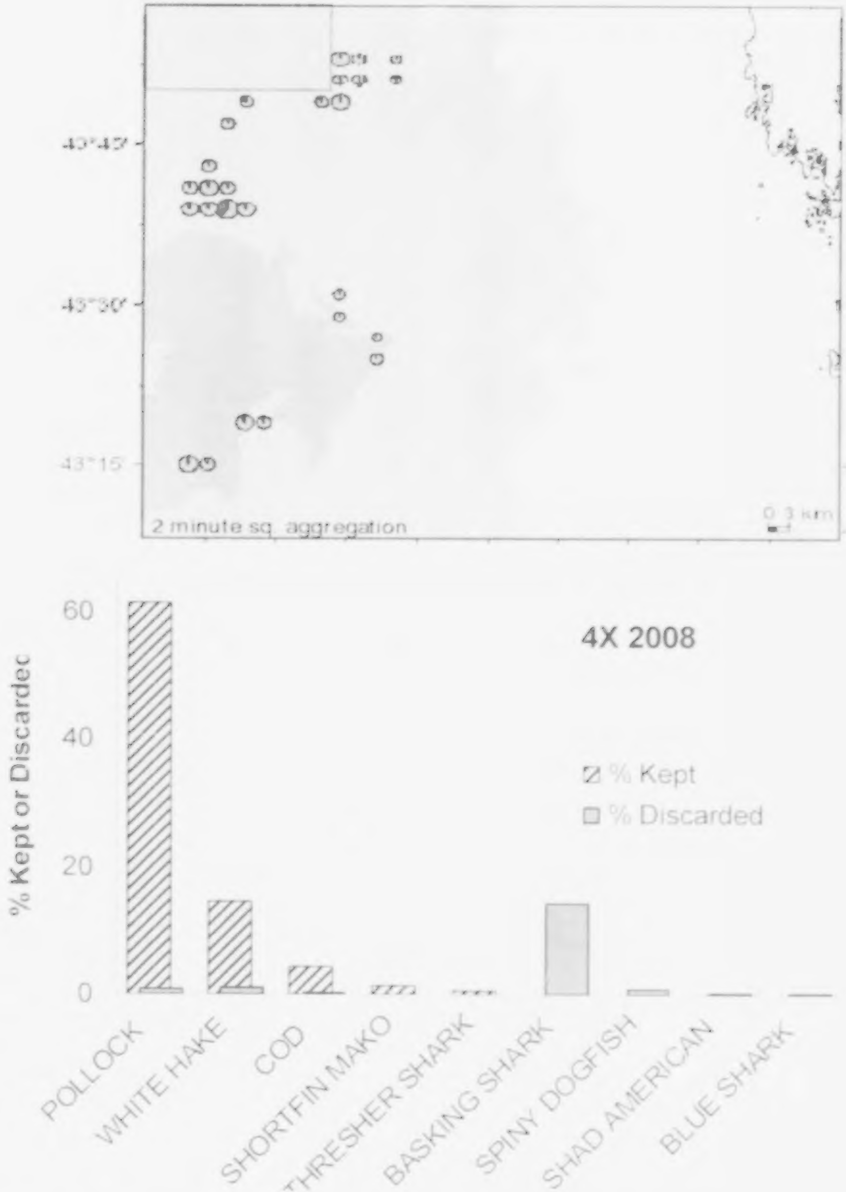


Fig. 44. Kept versus discarded bycatch reported for 2008 in 4X from pollock-directed observed gillnet trips. Top panel: observed set locations 4Xq; bottom panel: percentage of catch kept and discarded by species.

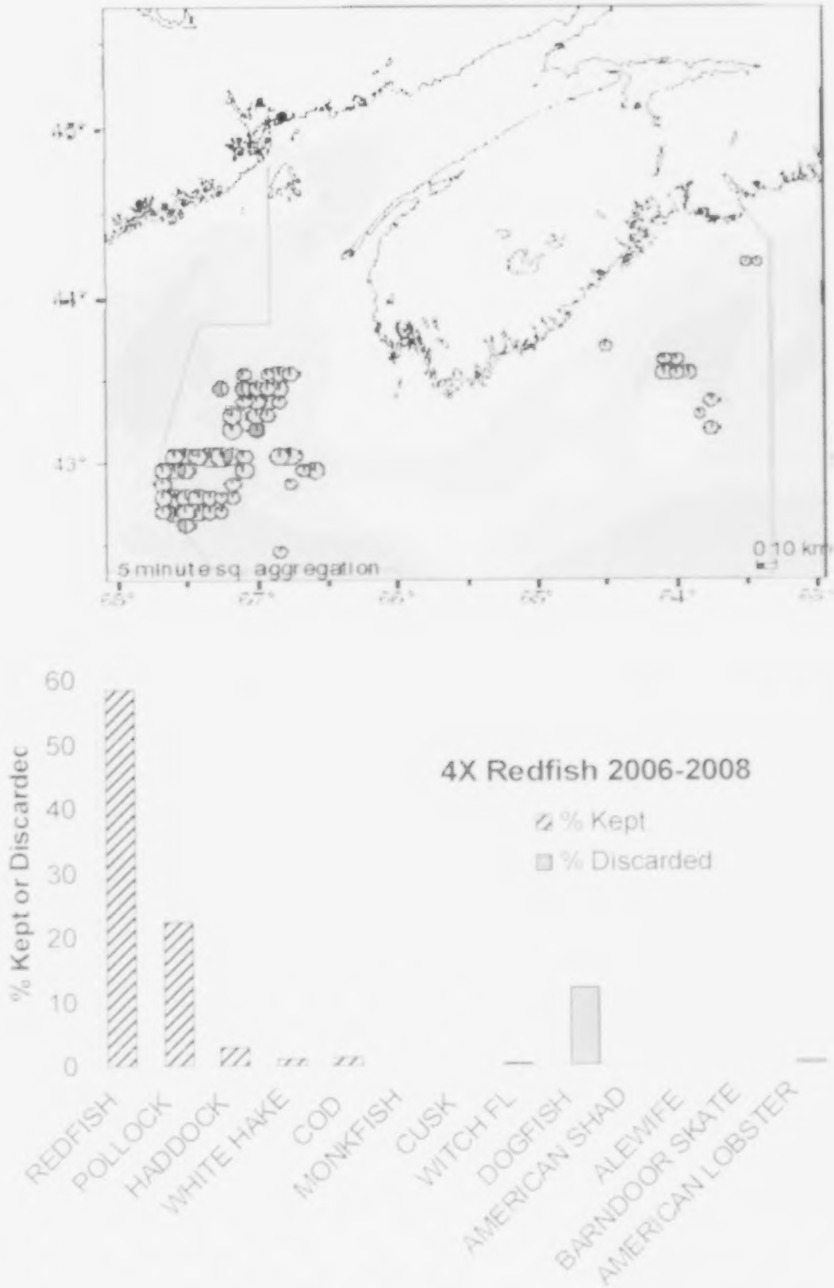


Fig. 45. Kept versus discarded bycatch reported for 2006-2008 combined observed trips in 4X from redfish-directed mobile gear trips. Top panel: observed set locations: 4Xpq and 4Xmn; bottom panel: percentage of catch kept and discarded by species.

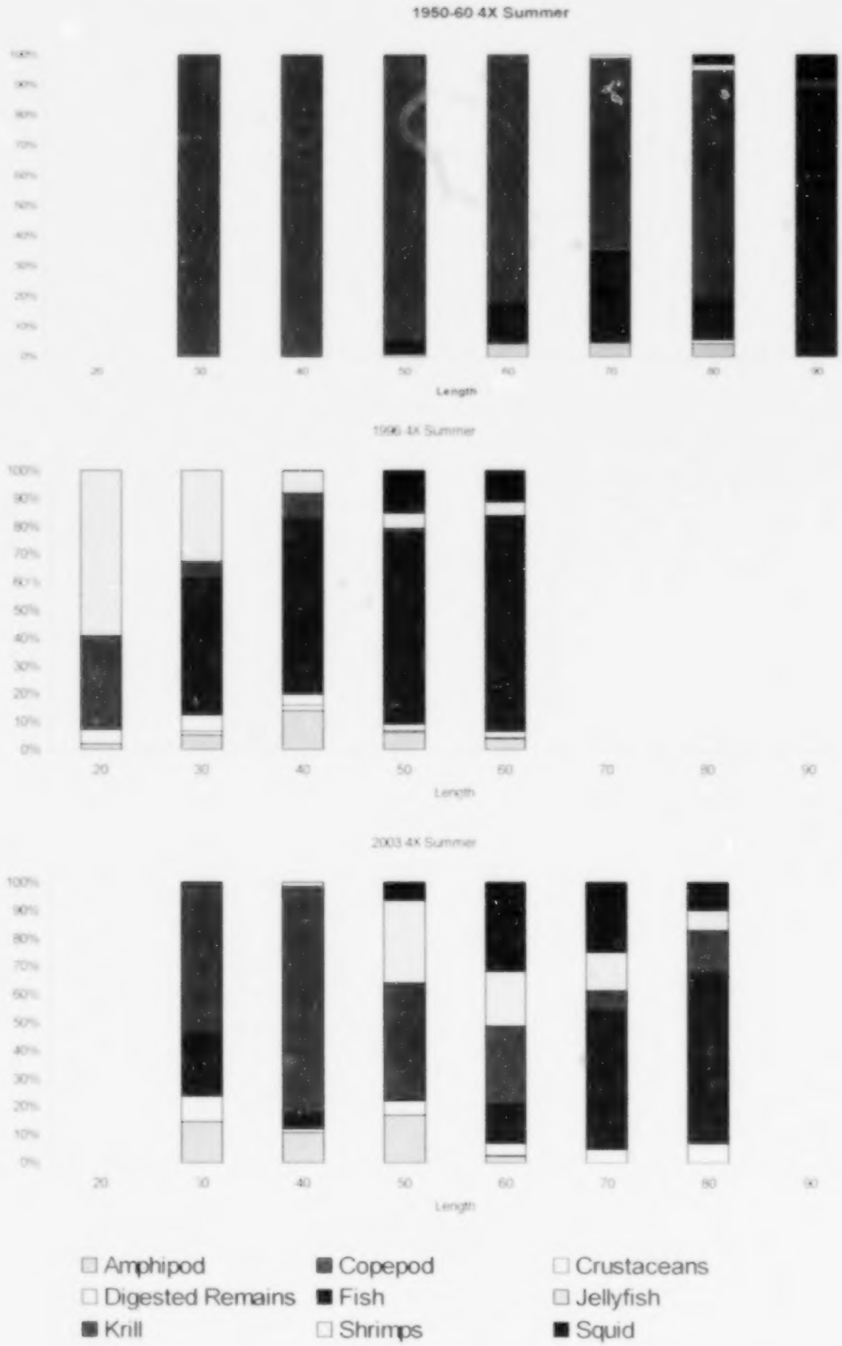


Fig. 46. Change in pollock diet (% of prey weight) by fish size (cm, FL) during summer in 4X through the 1960s (upper panel), 1996 (middle panel), and 2003 (lower panel), based on stomachs collected from DFO RV surveys.

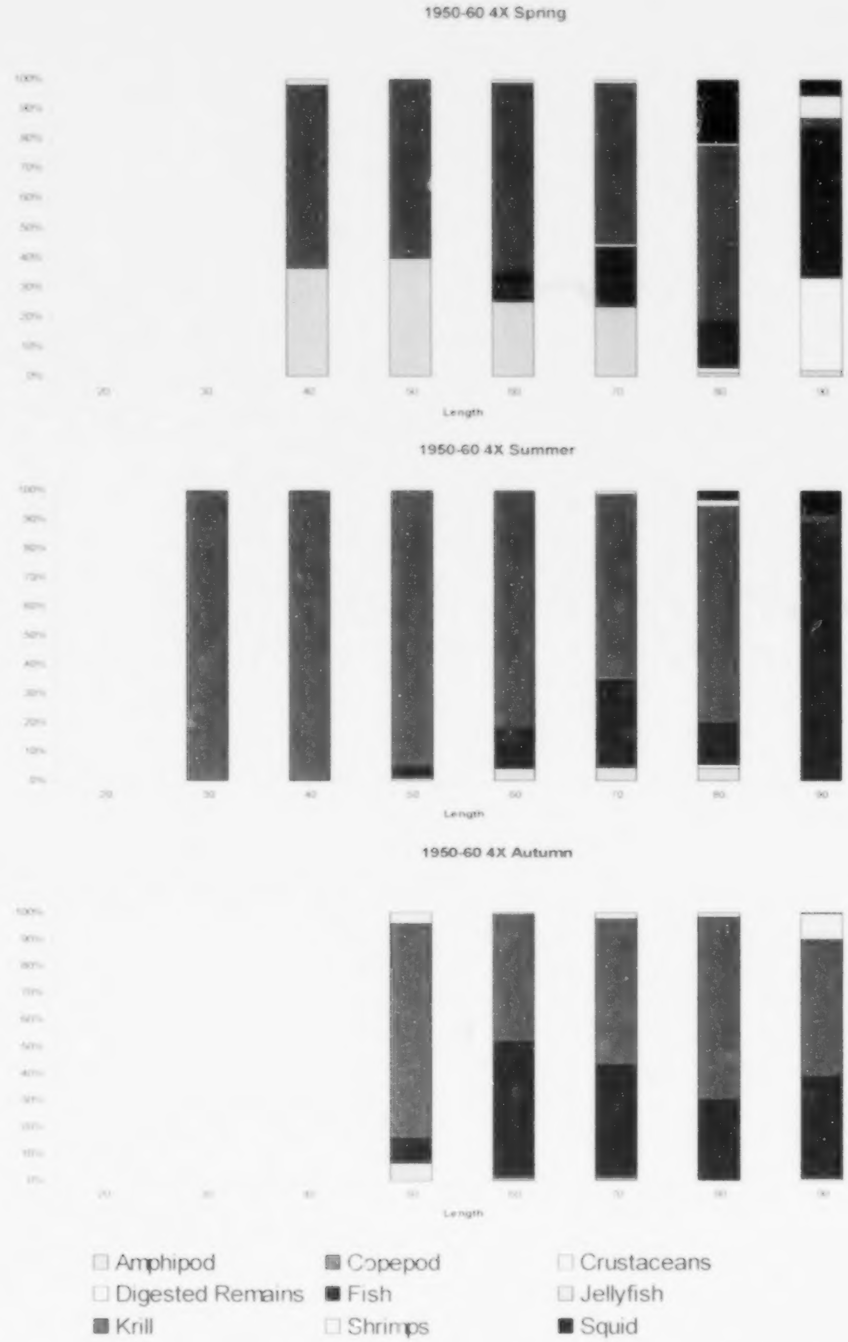


Fig. 47. Seasonal changes in diet of pollock (% of prey weight) by fish size (cm, FL) based on stomachs collected during the 1960s in 4X from DFO RV surveys (upper panel: spring; middle panel: summer; lower panel: autumn).

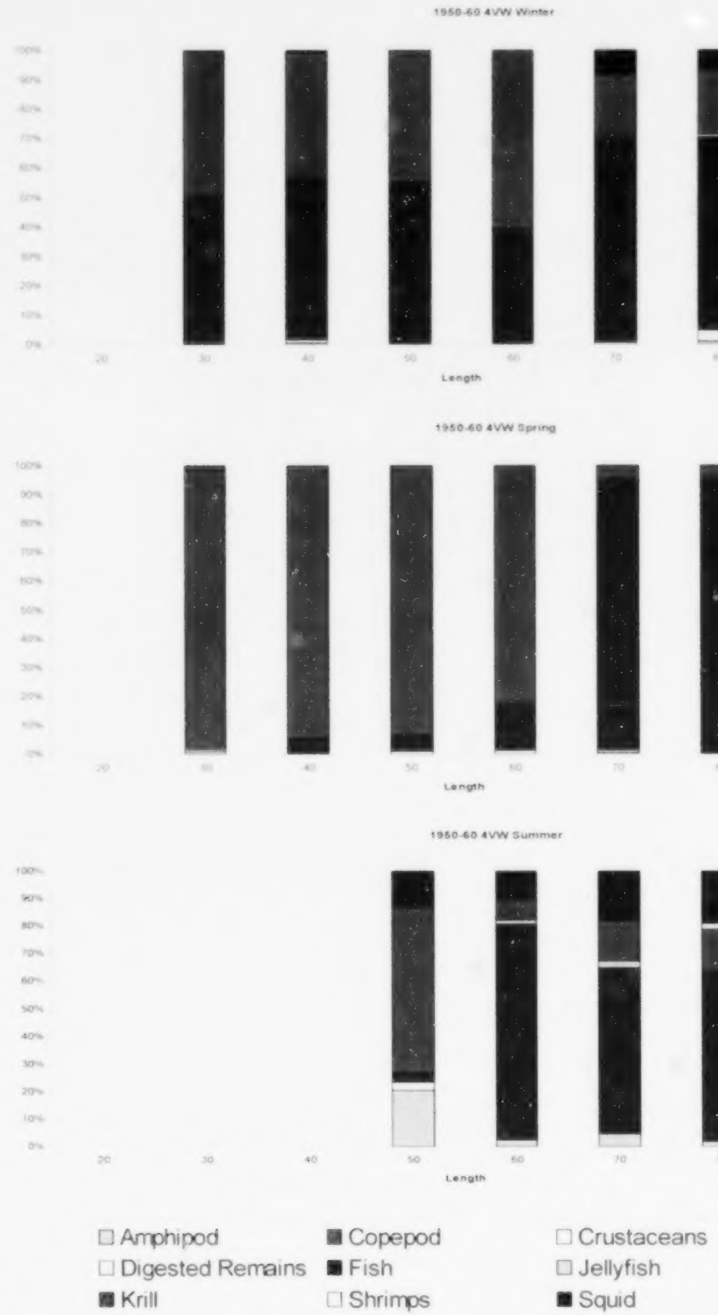


Fig. 48. Seasonal changes in diet of pollock (% of prey weight) by fish size (cm, FL) based on stomachs collected during the 1960s in 4VW from DFO RV surveys (upper panel: spring; middle panel: summer; lower panel: autumn).

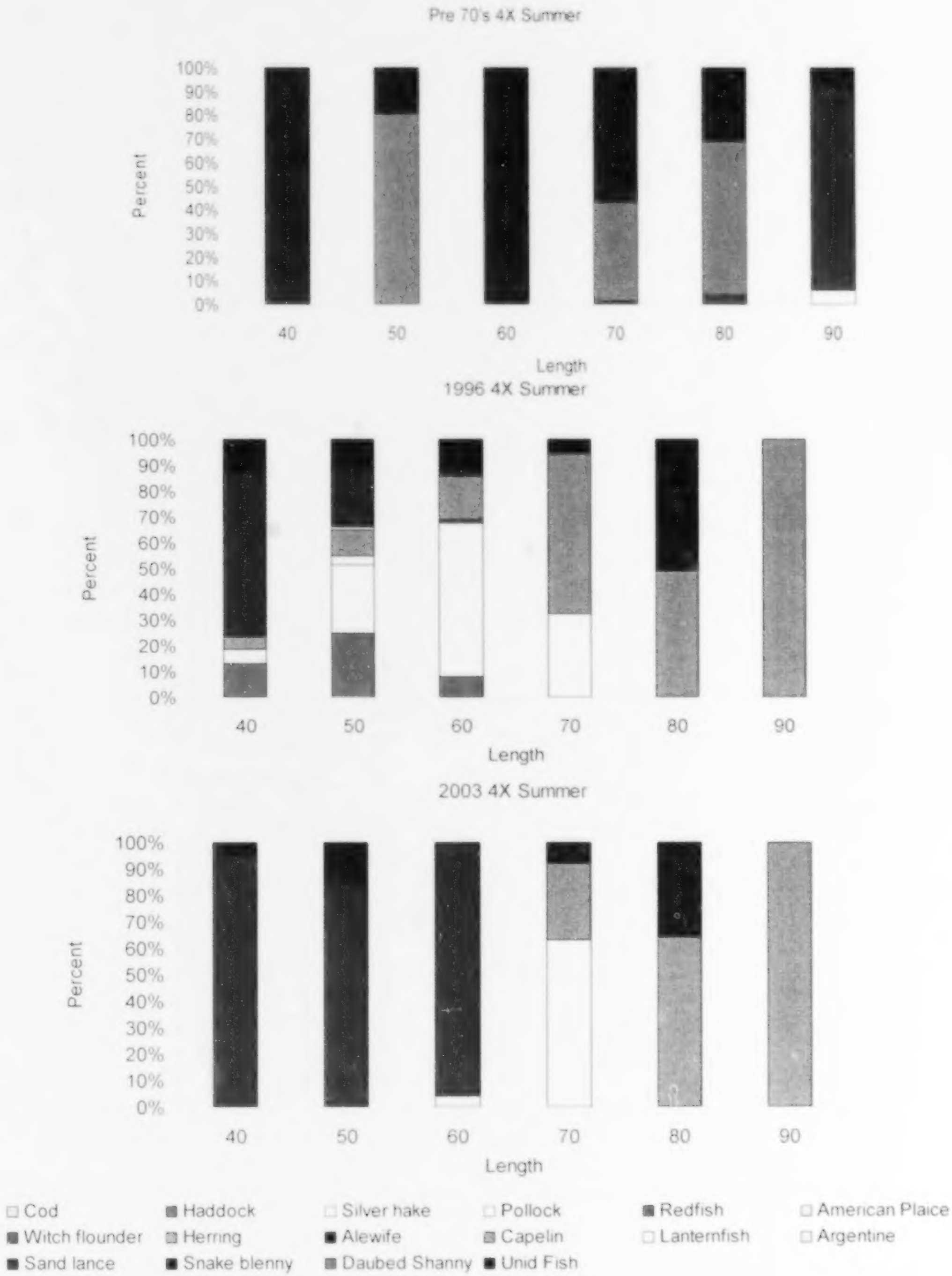


Fig. 49. Temporal stability of fish prey in pollock diet (% by weight) by fish size (cm, FL) based on stomachs collected from DFO RV surveys in 4X during the pre 1970s (upper panel), 1996 (middle panel), and 2003 (lower panel).

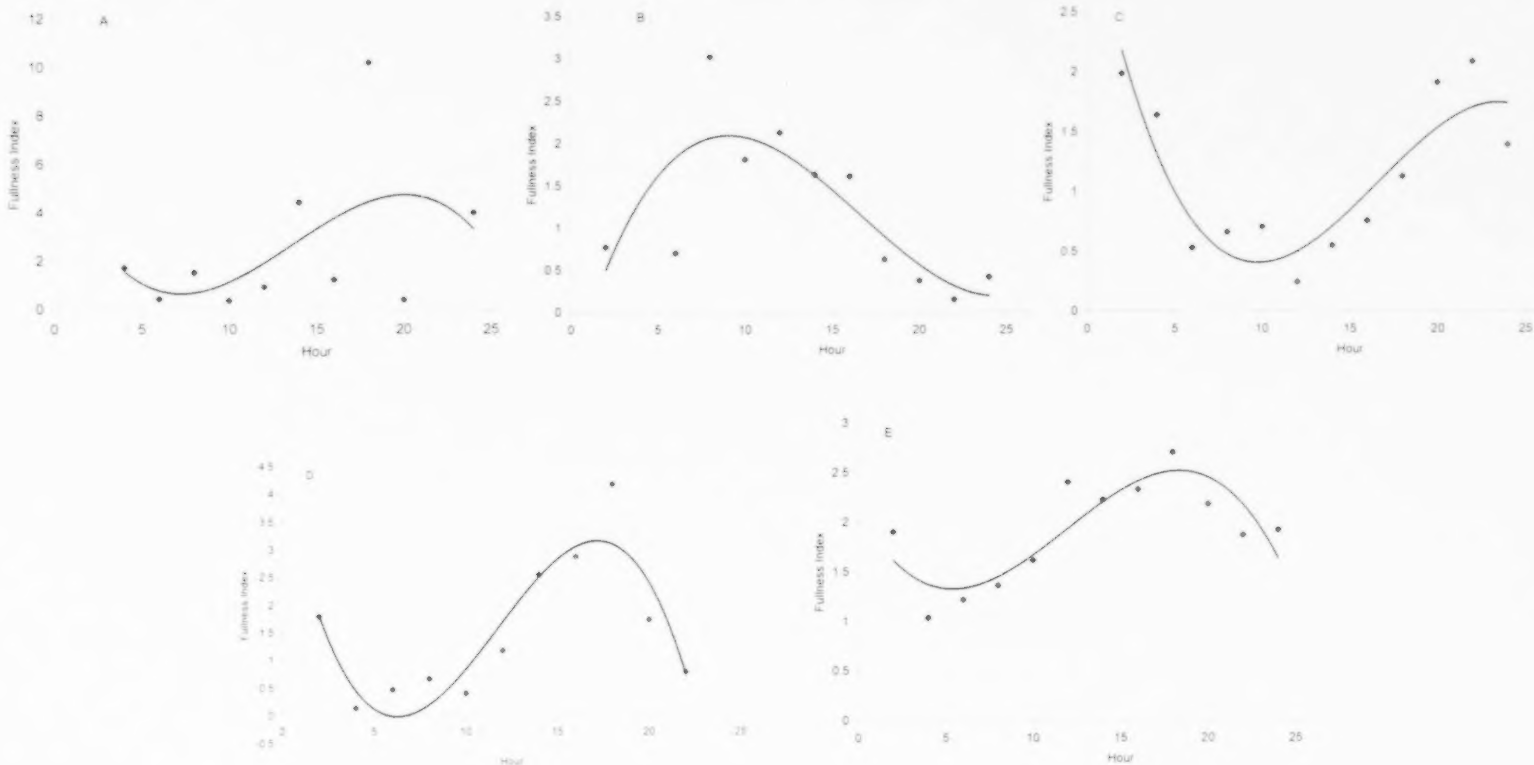


Figure 50. Diel feeding patterns (stomach fullness) for pollock collected during RV surveys during: A) pre 1970s summer, B) pre 1970s spring, C) pre 1970s winter, D) pre 1970s autumn, and E) 1995-2008 summer.

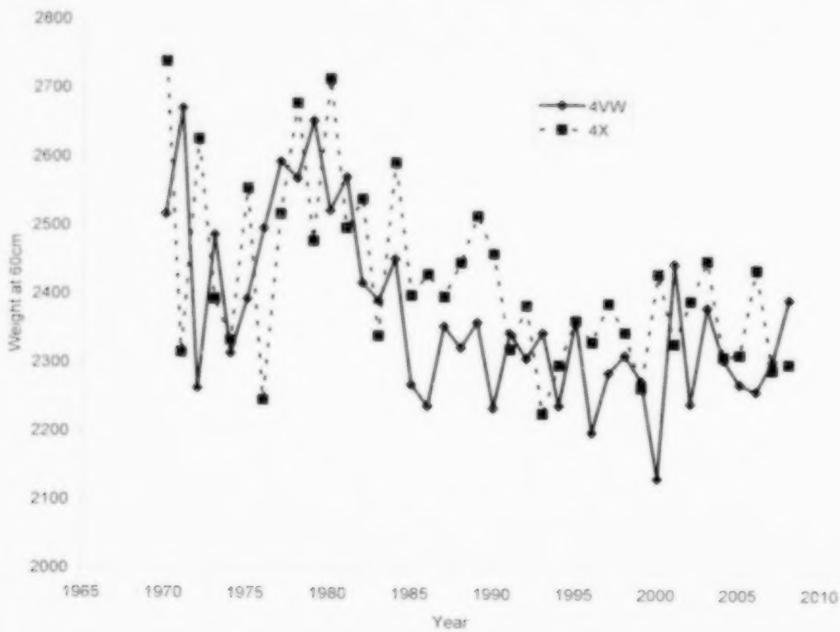


Fig. 51. Changes in the predicted weight (g) of pollock at 60 cm fork length based on length-weight relationships from DFO summer RV survey data, 1970-2008.